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Land Use and Water Quality in the Flathead Drainage

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ABSTRACT

Flathead Lake, Montana, and the streams and land in its drainage area, comprises some of the most scenic mountain environment in the United States. Flathead Lake and its contributing waters face serious degradation from man's activities and land uses. Rural-domestic wastewater, municipal sewage, livestock wastes, farming practices, subdivisions, recreation activity, forestry practices, industrial pollution, reservoirs, and the associated rapid population and economic growth in the area are major components of the water and land use problems in the drainage. Land use controls need to be implemented and strengthened to advert serious water quality degradation in the lake and its contributing streams.

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Objectives:

On May 15, 1972, the Environmental Protection Agency, Denver Office, contracted the University of Montana Biological Station to:
1) Compile existing data on water quality and land management practices affecting water quality in the Flathead drainage; 2) Evaluate methodologies employed in obtaining water quality data in this region, and examine methodologies presently utilized in land management activities to prevent deleterious effects to water quality; 3) Develop proposed methodologies for assessment of important ecological parameters toward prevention and abatement of water quality problems in the drainage, and suggest methods to prevent continued degradation of water quality from present land use activities.

A literature review and contact with appropriate agencies was conducted in order to determine the availability of data on the following: 1) Land and forest management, 2) Stream flow management, 3) Reservoir operation, 4) Irrigation return flows, 5) Recreation facilities and watercraft, 6) all forms of wastewater disposal, and 7) Animal wastes disposal. Biological Station personnel conducted studies and surveys in certain areas where information was badly lacking. When data could not be obtained, estimates were made by utilizing information obtained in other studies conducted elsewhere which appeared appropriate to the Flathead drainage.

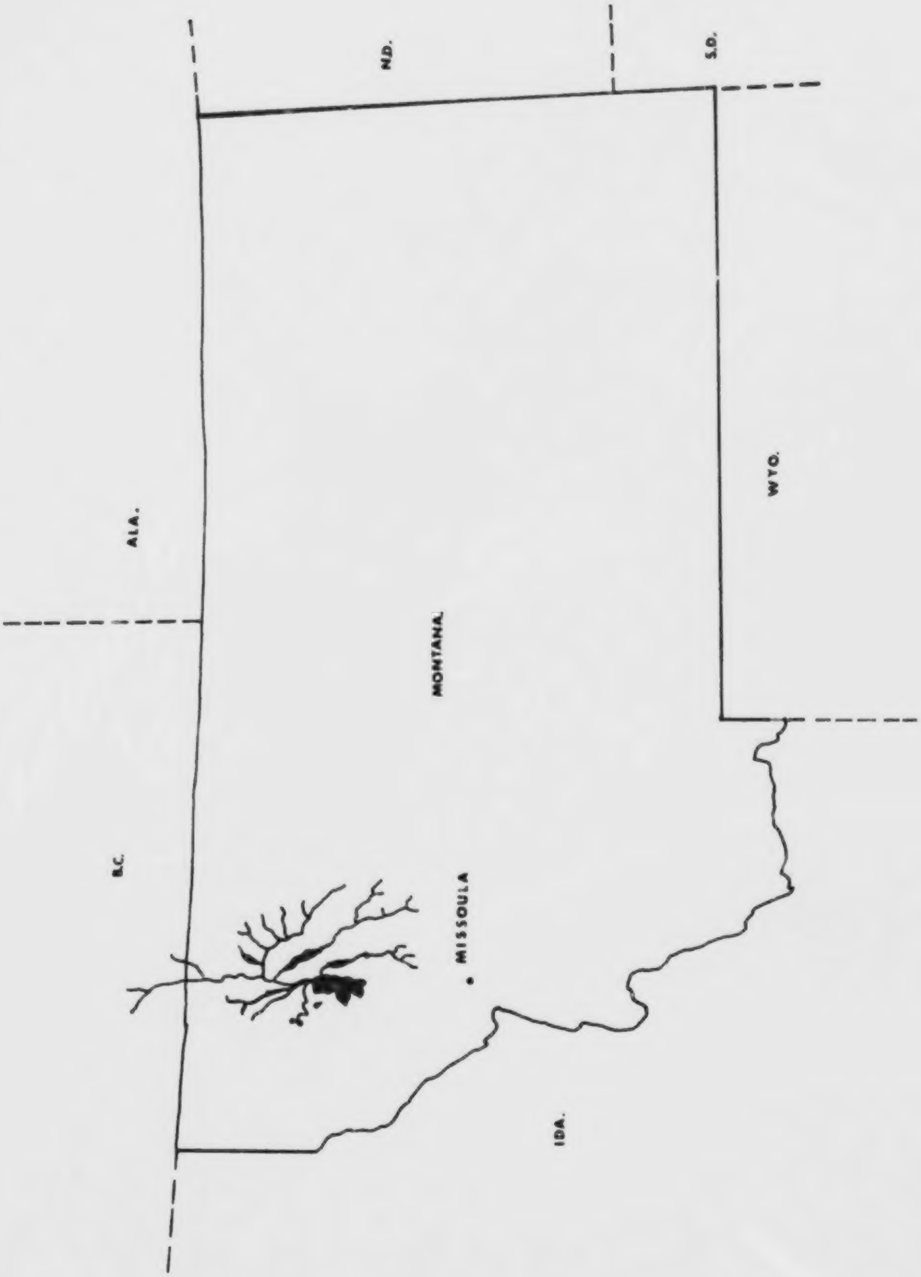
Population and economic statistics and trends were examined to gain some understanding of future development and management needs of the Flathead drainage. Much time was necessarily involved in gathering stream flow data, water quality data, and information on biological studies, including bacteriological, floral and faunal data that have been recorded for aquatic habitats in the drainage. Geological, climatological, and terrestrial floral and faunal information was also collected.

Agencies contacted in carrying out this work: Flathead National Forest, United States Geological Survey, Glacier National Park, Soil Conservation Service, Bureau of Reclamation (Boise, Idaho and Spokane, Washington), United States Army Corps of Engineers (Seattle), Environmental Protection Agency (Seattle), Pacific Northwest River Basins Commission, Montana Fish and Game, Montana State Department of Health and Environmental Sciences, Montana Water Resources Board, Montana Department of Planning and Economic Development, Joint Montana University Water Resources Research Center, Lake and Flathead County Sanitarian's offices.

Acknowledgments:

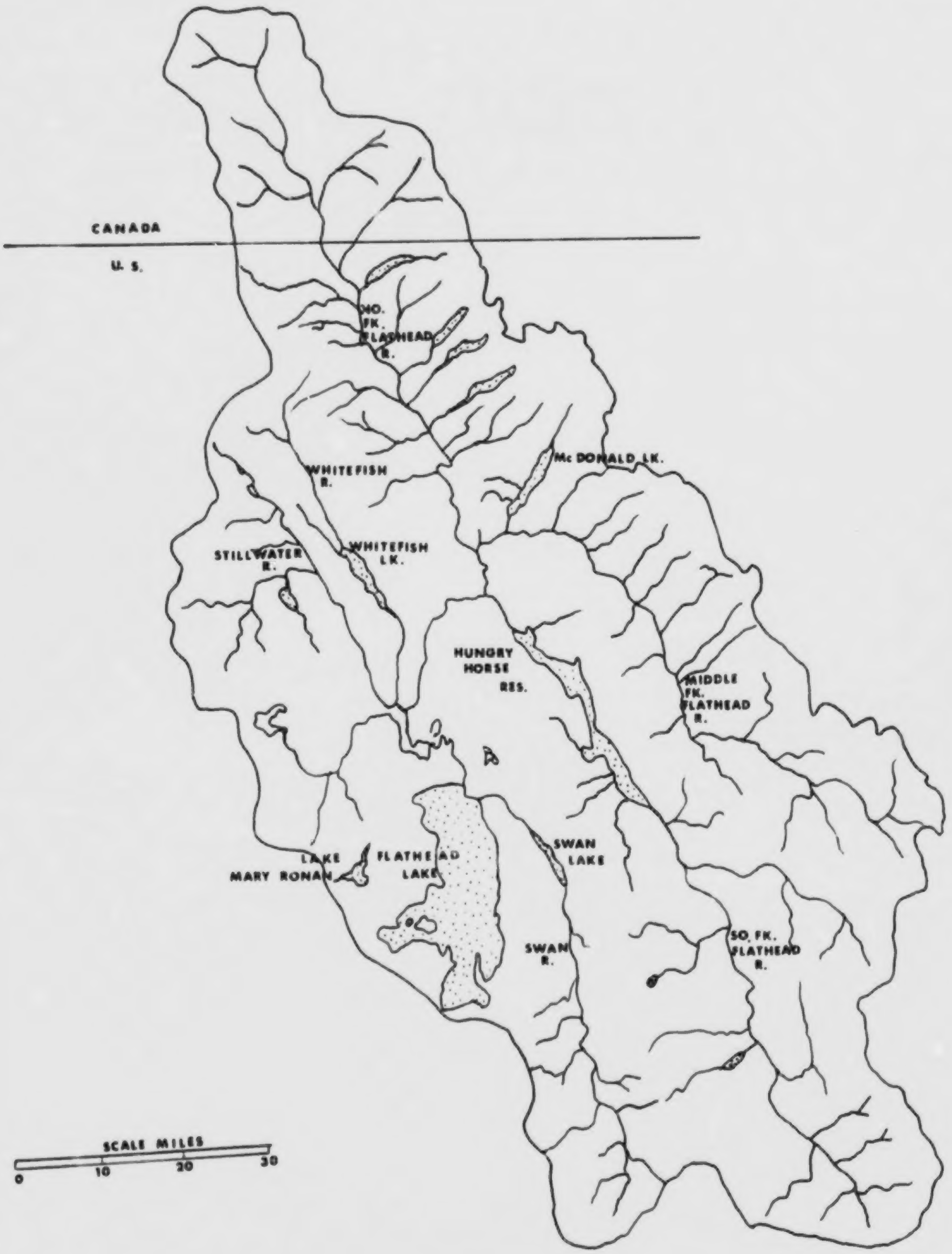
We gratefully acknowledge the data, comments and criticisms from the following persons: Dr. Arden Gaufin, University of Utah; Dr. Richard Konizeski, University of Montana; Mr. Wilbur Aikin and Mr. David Nunnallee, Montana State Department of Health and Environmental Sciences; Mr. Robert Schumacher and Mr. Delano Hanzel, Montana Department of Fish & Game; Mr. Robert Delk, Flathead National Forest; and personnel of the several Counties Sanitarians' offices.

DRAINAGE AREA OF FLATHEAD LAKE


B.C.
ALA.
N.D.
S.D.
MONTANA
WYO.
MISSOULA
IDA.

THE FLATHEAD DRAINAGE TO FLATHEAD LAKE

Figure 2


CANADA
U. S.
NO. FK. FLATHEAD R.
McDONALD LK.
WHITEFISH R.
STILLWATER R.
WHITEFISH LK.
HUNGRY HORSE RES.
MIDDLE FK. FLATHEAD R.
LAKE MARY RONAN
FLATHEAD LAKE
SWAN LAKE
SWAN R.
SO. FK. FLATHEAD R.
SCALE MILES
0
10
20
30

Previous Studies

No agency has studied land management with respect to its affect on water quality in the drainage. The Bureau of Reclamation surveyed the Kalispell Valley for irrigation potential (1951) and later made a reconnaissance report of the entire Clark Fork drainage (1959). Situation statements have recently been published on both Flathead and Lake Counties (U.S.D.A. extension offices, 1972). Various comprehensive sewage and water use plans have been reported for communities and counties within the study area (Thomas, et al, 1968; Petrini, et al, 1971; Turnbull and Plummer, 1972; Montana Dept. of Planning and Economic Development, 1970). Water resources with respect to water use in Lake and Flathead counties were surveyed by the Water Resources Board in 1963 and 1965 respectively.

Currently, the Department of Natural Resources and Conservation is conducting a land use inventory within the study area between Bigfork and Echo Lake. That study will look at land use and its effects on water quality. Flathead County is commencing a comprehensive land use plan for that county that will prepare the way for county-wide zoning.

Specific land use and pollution studies have been done within limited areas of the study area. Bover (1969) sampled for coliform bacteria as a result of human sewage in Flathead Lake. Hern (1970) repeated this study and included the lower part of the Upper Flathead Mainstem and tributaries in his research. Casey (1971) measured thermal increases in a stream caused by a clearcut in the North Fork drainage area. Spindler (1957) determined the effects of Kalispell sewage on Ashley Creek, and measured water quality on certain rivers in the drainage. Numerous other studies by University of Montana Biological Station personnel, Montana Fish and Game Dept., and U.S. Geological Survey have obtained water quality data, but have not attempted to correlate this data with land use activities.

History of the Region

White settlement occurred relatively late in the 19th century. Prior to the 1820's the land was wilderness and belonged to Indians of the Salish Tribal Nation. The rate of settlement was slow but steady, and was enhanced by the coming of the Great Northern Railroad in 1891. Lumber was, and remains, a principle industry of the area. The Stillwater, Whitefish, Flathead and Swan Rivers served as transport systems for the earliest lumber center, Somers, located on the northwest shore of Flathead Lake.

Flathead Lake served as a transport system from Polson to points north until a road (now Highway 93) was built along the west side of the lake. Steamboats carried passengers and cargo to points along the lake and upper Flathead River. As a result, almost all virgin timber around the lake was cut to fuel these boats. The land now occupied by the University of Montana Biological Station represents the largest tract of relatively pristine forest along the lake.

The Flathead River system remained largely unmodified until the construction of Kerr Dam below Polson in 1938. The dam regulates the upper ten feet of Flathead Lake and has a capacity of 1,219,000 acre-feet. (Montana Water Resources Board, 1968).

The Flathead drainage system was significantly modified by the Hungry Horse Reservoir. This dam began operation in 1953 on the South Fork of the Flathead River; the dam has a capacity of 3,468,000 acre-feet (ibid). The dam regulates much of the spring run-off on the South Fork, reducing the flow of the Flathead River during this period. Conversely, the dam discharges water during other periods of the year, correspondingly increasing the volume of the Flathead River.

Geology of the Flathead Drainage

The geological processes which have resulted in the present rugged terrain of the Flathead drainage have been discussed by many investigators. A current review can be found in Silverman (1971) and Johns (1970).

Two major occurrences have been responsible for present land structure. The first and most significant event, was the tremendous crustal deformation that occurred in the Late Cretaceous Period, and which is responsible for the mountain formation in the area. Pre-Cambrian sediments predominantly Ravalli quartzite and Piegan limestones compose much of the present mountain formations. The second factor responsible for much of the present land conditions, lakes and drainages, was the massive glaciation, especially the last glacial advance of the late Wisconsin age (Fig. 1). The moraines left by this last ice movement are directly responsible for the formation of Lake Mary Ronan and Flathead Lake's present configuration (Smith, 1966). Konizeski (1968), reports that Whitefish Lake is also of similar origin. He further states that the Flathead arm of Glacial Lake Missoula "inundated the entire Kalispell Valley to an altitude of 4,200 feet. Sand, silt, and clay (glacier flour) accumulated in the glacial lake to a thickness of several hundred feet" and covered older deposits, (Konizeski, 1968). These lacustrine deposits, then, along with numerous moraines and glacial debris, compose much of the subsoils in the lower areas (below 3,400 feet). Konizeski (ibid) found that Tertiary and Quaternary deposits were as much as 4,800 feet deep in the Kalispell Valley.

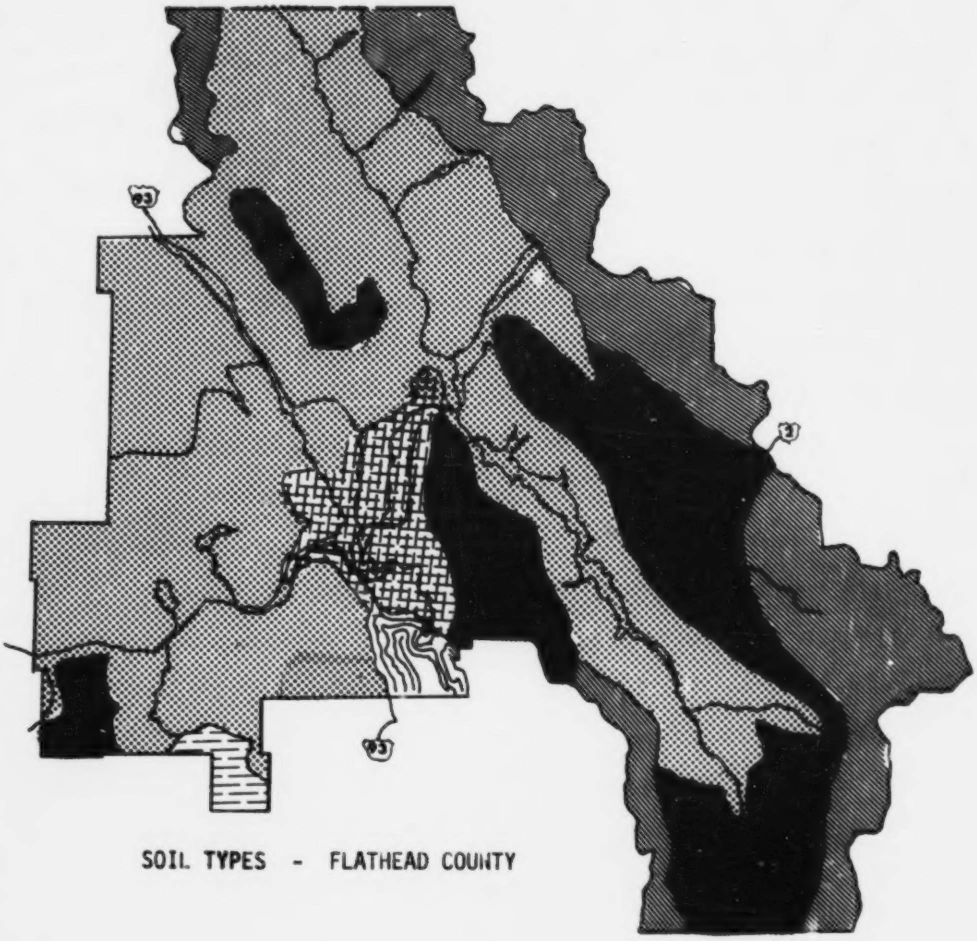
Soils

Soil formations that occur in the Flathead drainage have had only about 12,000 years to evolve. Previous to that time the glaciers had scoured out any prehistoric soil during the last ice advance. Hence, soils are usually very thin except where aluvial, lacustrine or aeolian deposits of silt, sand or clay can be found. These areas are almost entirely within the Kalispell Valley.

A comprehensive study of soil types was conducted by the Soil Conservation Service and Montana Agricultural Experiment Station for the Kalispell Valley (1946). A generalized soil map for Flathead County is represented by Figure 3.

In relation to runoff, soils under natural vegetation are generally very stable. The Columbia-North Pacific Study (1971) found that the sediment yield in rivers was very low for most of the study area, between .02 and .1 acre-feet per square mile per year. Most of Glacier National Park and the Middle Fork area lost about 0.1 to 0.2 acre feet per year, while the south west portion of the study area eroded 0.2 to 0.5 acre-feet per year. Limestone silts in the Middle Fork area cause the clear water of the Middle Fork River to appear a blue green hue even during low flow periods. Lacustrine silt deposits to the west side and below the study area cause a much more apparent coloring of the Flathead River below Polson.

Figure 3



SOIL TYPES - FLATHEAD COUNTY

▦ Dominantly Chernozem and Chestnut soils with associated Solodized-Solonetz and Alluvial soils along streams.

▩ Dominantly Gray Wooded soils.

■ Dominantly Brown Podzolic soils.

▨ Steep mountainous land above 8500 feet.

▤ Dominantly Lithosois and associated Solodized-Solonetz soils.

Note: Alluvial soils occur along most streams but in areas too small to show on the map.

(Water Resources Survey, Flathead County, 1965)

Vegetation and Wildlife

Over 90 percent of the Flathead drainage is forested. Flathead County reports that the predominant species of trees are the lodgepole pine, Douglas fir, western larch and Englemann spruce. (Table 1).

Table 1: species composition in Flathead County

Species	Precent of area
Lodgepole Pine	26
Douglas Fir	19
Western Larch	19
Englemann Spruce	17
Sub-Alpine Fir	13
White Pine	1
Ponderosa Pine	1
White Bark Pine	3
Other Species	2

(USDA, Flathead Co. Committee for Rural Development, 1972)

Species composition is somewhat similar for other counties in the study area, however, Missoula, Powell, and Lewis and Clark Counties contain less lodgepole pine.

Pfister, Arno, Presby, and Kovalchik (1972) have described eight habitat types of western Montana Forests, all of which occur in the study area. The reader is referred to their study for detailed species composition.

Many of North America's big game animals can be found in the Flathead drainage. Moose, elk, bighorn sheep, mountain goat, mule deer, and white-tail deer exist in the mountains of the drainage. Large carnivores including grizzly and black bears, wolf, mountain lion and wolverine occur in limited numbers. Both golden and bald eagles nest in the drainage. Over 300 bald eagles were observed by Seastedt in the lower McDonald Creek area in Glacier National Park on one day in November, 1969. Numerous species of smaller mammals and birds are to be found. In recent times, it appears that only the bison has been totally eliminated from the terrestial vertebrate fauna. Population dynamics of many species have suffered severe modifications as the result of human activities.

One member of the aquatic fauna, the west-slope cutthroat trout, a rare and endangered species, can still be found in fair numbers in the drainage.

Protective measures required to maintain fish and wildlife habitat have been prescribed by the Bureau of Sport Fisheries and Wildlife (Spokane office 1972) and by Robert Schumacher of the Montana Fish and Game Department (1972). These proposals are included in Appendix I.

Climatology

Monthly temperatures and precipitation for various stations in the drainage have been recorded for over fifty years at some locations. Precipitation records for Kalispell were initiated in 1897.

Mountain ranges are responsible for varying local climatological differences. The western side of the study area is in a rain shadow and receives less rainfall than the comparable altitudes on the east side of the study area. The growing season varies from about 150 days at Kalispell to an estimated 30 days in the high mountainous areas.

Flathead Lake can be shown to modify local weather conditions somewhat, especially on the east side of the lake. Bigfork, Montana has the warmest annual temperatures, and is cooler in the summer and warmer in the winter than other stations in the drainage. Weather modifications by the Lake, then, is responsible for the ability of the east side to support a local cherry orchard industry.

A summary of monthly mean values for temperature and precipitation is as follows:

Mean Temperature Values in Degrees Farenheit

Location	Years on record	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ann
Bigfork, 12S	21	26.2	29.8	35.2	45.2	53.5	59.1	61.5	65.9	57.1	47.0	35.3	31.0	46.1
Hungry Horse Dam	13	19.5	24.7	29.9	40.8	51.1	57.6	65.0	63.1	54.3	43.1	31.4	26.2	42.2
Kalispell	38	21.4	25.2	33.1	43.7	52.0	58.4	68.4	63.3	54.0	43.9	32.2	24.9	43.2
Polson Airport	47	24.1	27.7	33.2	44.7	52.7	59.9	67.5	65.8	56.2	46.1	34.7	28.6	45.1
West Glacier	46	20.8	24.6	31.7	41.8	50.5	57.0	64.5	62.5	53.2	42.9	30.9	24.3	42.1

Total Precipitation

Location	Years on record	Jan.	Feb.	Mar.	Apr.	May	Jun..	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ann
Bigfork, 12S	22	1.86	1.42	1.15	1.75	2.46	3.18	1.28	1.31	1.58	1.91	2.09	1.92	21.91
Hungry Horse Dam	13	3.65	2.71	1.93	2.02	2.49	2.94	1.58	2.05	2.13	3.33	3.29	3.02	31.14
Kalispell	65 13 52	1.51 1.28 1.57	1.12 1.14 1.11	0.92 .81 0.95	0.87 1.17 0.80	1.51 1.71 1.46	2.05 2.02 2.06	1.13 1.26 1.10	1.00 1.52 0.87	1.17 .87 1.24	1.08 1.18 1.06	1.36 1.40 1.35	1.42 1.31 1.45	15.15 15.67 15.02
Polson Airport	49	1.11	.93	.94	1.17	1.74	2.24	1.02	.94	1.32	1.23	1.26	1.24	15.14
Kerr Dam	30	1.07	0.91	0.78	1.23	2.03	2.44	0.99	1.08	1.35	1.20	1.28	1.18	15.54
West Glacier	45	3.10	2.34	1.74	1.73	2.20	2.83	1.44	1.39	2.02	2.64	2.91	3.24	27.58
Whitefish 5 NW	21	2.13	1.80	1.34	1.58	2.29	2.88	1.39	1.46	1.46	1.74	2.19	1.97	22.[illegible]

Snowfall averages are as follows: (U.S. Weather Bureau statistics)

Location	Snowfall (amount in inches)	# of Years Recorded
Kalispell	49.4	50
Polson	37.5	20
West Glacier	137.0	32
Whitefish	67.0	13
Hungry Horse	110.5	15

Precipitation and runoff maps are available in the "Columbia-North Pacific Comprehensive Framework Study", Appendix V, Vol. I. Annual rainfall varies from 15 inches in the Kalispell Valley to perhaps up to 100 inches in the high mountains on the east side. Likewise, runoff varies from less than 5 inches in the Kalispell Valley to over 40 inches in the mountains.

Surface Waters

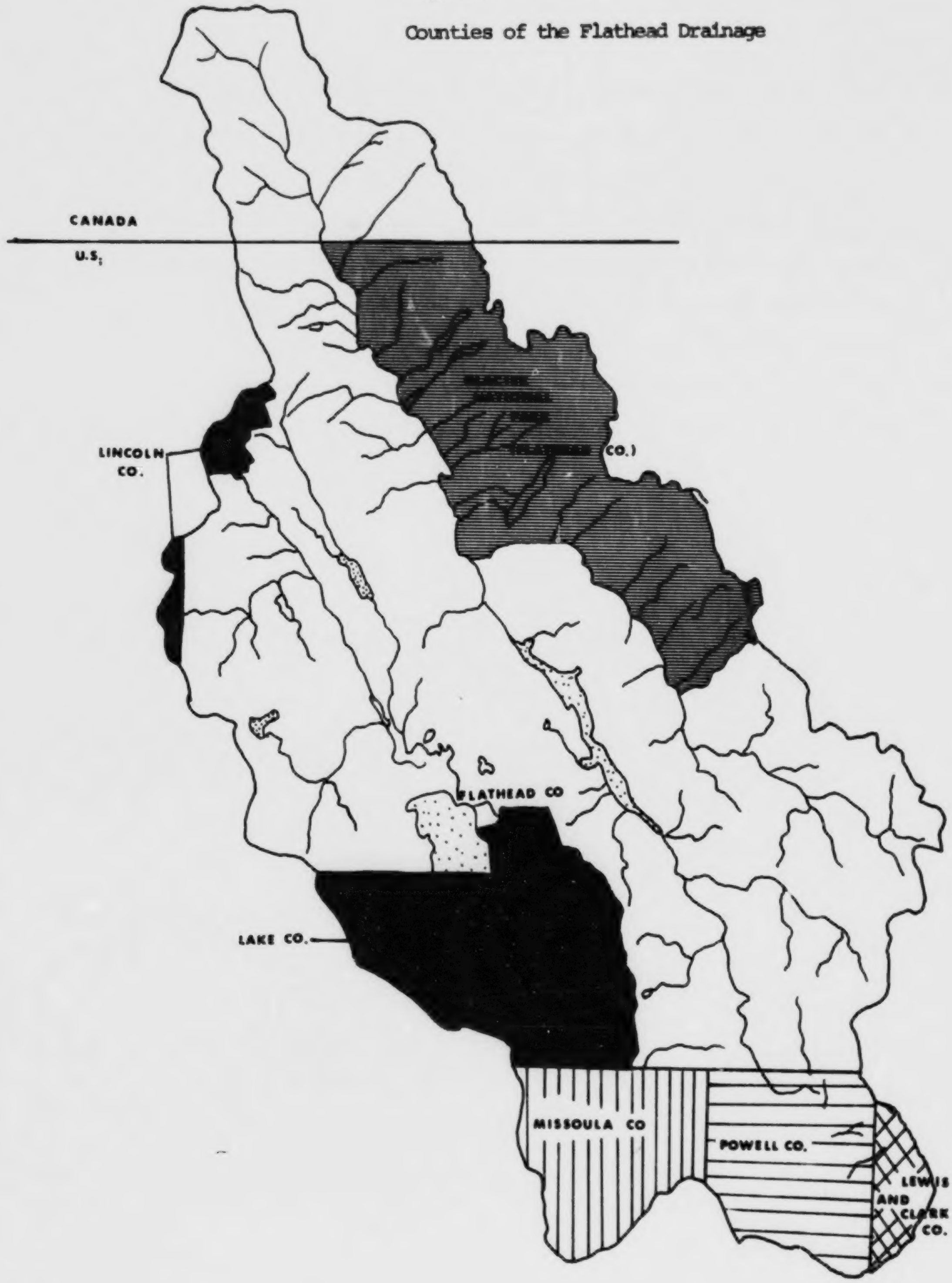
The drainage area of Flathead Lake at Polson encompasses approximately 7010 square miles in Montana and Canada. The North Fork of the Flathead River, at the international border has a drainage area of about 450 square miles in Canada, with an additional 175 square miles of drainage in Canada that flows into tributaries that enter the North Fork below the border. Of approximately 6,375 square miles of the drainage in Montana, 4,550 are in Flathead County and 850 square miles are in Lake County. Powell, Missoula, Lincoln and Lewis and Clark Counties contain about 425, 410, 90, and 65 square miles of the Flathead drainage respectively (Fig. 3). All of Glacier National Park west of the divide, or 875 square miles, and most of Flathead National Forest's 3,680 square miles are located in the drainage. The major rivers include the South, North, and Middle Forks of the Flathead River which join to form the Flathead River at Columbia Falls, Montana. The Whitefish and Stillwater Rivers merge and empty into the Flathead River below Kalispell. The Swan River enters directly into Flathead Lake at Bigfork, Montana (Fig. 4).

An average of 8,405,000 acre feet of water flow through the gaging station near Polson yearly (11,610 cfs average). The average flow of the Flathead River as it empties into Flathead Lake has not been gaged but is estimated to average between 9,500 to 11,000 cfs. The Swan River near Bigfork discharges an average of 1,127 cfs to Flathead Lake.

The largest tributary of the Upper Flathead River is the South Fork, which discharges an average of 3,523 cfs as modified by Hungry Horse Dam. Next largest is the North Fork, discharging an average of about 3,000 cfs over the year. The Middle Fork discharges about 2,920 cfs average at the

Figure 4

Counties of the Flathead Drainage


CANADA
U.S.
CO.)
LINCOLN CO.
FLATHEAD CO
LAKE CO.
MISSOULA CO
POWELL CO.
LEWIS AND CLARK CO.

junction with the North Fork, forming the Flathead River Mainstem. The Stillwater and Whitefish Rivers discharge an estimated average respectively of 350 cfs and 200 cfs as they empty into the Flathead River.

The Upper Flathead drainage contains literally hundreds of lakes ranging from high alpine oligotrophic lakes to dystrophic bogs. This report places special emphasis on Flathead Lake, Whitefish Lake, and Lake Mary Ronan. All waterways, lakes, streams, and groundwater supplies that drain into Flathead Lake are the concern of this report, but discussion has generally been limited to the above three lakes unless specific problems on other lakes were brought to the attention of the investigators during the course of study.

Groundwater

The only comprehensive study of groundwater within the Flathead drainage was conducted by Konizeski et al. (1968) for the upper Kalispell Valley. He delineated six types of aquifers: flood plain gravel, deep artesian, dune sand, outwash sand and gravel, flood plain sand, and Precambrian bedrock. Of these, all but the deep artesian and Precambrian bedrock aquifers could be subject to pollution by industrial and domestic wastes and sewage. Chemical analysis of select wells is presented in Appendix IV. Dune sand aquifers were particularly prone to high nitrate content, and the four aquifers subject to contamination average 41.4 milligrams per liter (mg/l) nitrates.

Konizeski found that the flood plain gravel aquifer stores about 170,000 acre-feet of water and discharges 21,000 acre feet to streams per year. Assuming total movement and mixing within this aquifer (a questionable assumption) retention time would be about 8 years. Movement of groundwater was found to be less than 0.1 feet per day for deep artesian aquifers, to 50 feet per day for the gravel aquifer.

Groundwater levels fluctuate with the season, generally reaching a low in early spring. The sand aquifer on the flood plain north of the Lake has been shown by Konizeski to be directly correlated with the regulated levels of Flathead Lake.

Changes in groundwater quality and quantity could be altered by the spectrum of man's activities including: 1) clear-cutting (increased recharge, nitrate enrichment); 2) irrigation (increased recharge, nutrient enrichment); 3) livestock (possible decreased recharge by compacting soil, nutrient enrichment); 4) industrial settling ponds (increased recharge, phenols, and other solutes); 5) septic tanks (increased recharge, nutrient enrichment); 6) roads, housing and other activities which compact the soil could lessen recharge potential.

Each of the above activities is discussed as it relates to groundwater in the respective sections of each below.

Mining

The search for precious metals in the Flathead drainage occured in the late 19th and early 20th centuries. Very little was found, however, and few scars note early attempts to mine for gold, silver and copper. Few mineral deposits in concentrations of economic value are present in the drainage (Flathead National Forest, 1972). Barite deposits occur in the South Fork of the Flathead of commercial quality, but lack of access make mining uneconomical. Aikin (pers. comm.) reports that only six patented mining claims exist in the Flathead National Forest.

The presence of coal, reported by Rowe (1933), is found in the three forks of the Flathead River. He stated that over three billion metric tons exist in the field. Some coal was mined on private lands near Coal Creek in the North Fork, but this operation closed in 1930. Future energy requirements might result in the removal of these deposits, however, the coal is not of high quality. Furthermore, the environmental problems encountered in removal are many and perhaps insurmountable. It is doubtful that these deposits will be mined in the foreseeable future (Tomlinson, pers. comm.).

No known water pollution problems are known to exist from the very limited number of mines in existence in the Flathead drainage.

Survey of Water Quality Studies on Flathead Lake

Flathead Lake has basically been studied from an ecological viewpoint, with chemical and physical characteristics being studied as parameters of the biota. Forbes (1893), conducted the first survey of invertebrates. Elrod (1899, 1901, 1902, 1903), and Elrod, Clapp, Young, Shallenberger and Howard, (1929), conducted a series of limnological investigations on and around the lake. The bacteria of the lake were first studied in 1934 (Graham and Young, 1934). Later studies on bacteria were conducted by Potter and Baker (1956, 1961).

Young (1935), accumulated data of many co-workers to report on the physical, chemical and biological conditions of Flathead Lake.

More recent works on phytoplankton, zooplankton, fisheries, and chemical and physical properties of Flathead Lake have produced an abundance of data. Bjork (1967) and Tibbs and Potter (1972), have reported on zooplankton and its distribution and ecology. Recent phytoplankton studies include work by Moghadam (1969), Morgan (1968), (1970) and Hanzel (1971). The Montana Fish and Game Department has surveyed fish populations along with physical and chemical characteristics of the lake (Hanzel, 1964, 1969, 1970, 1971, 1972). Continuing work is underway on phytoplankton productivity and zooplankton (Ivory, in progress; Potter, in progress). A summary of plankton populations, distributions and ecology has been included in Appendix II. (From Morgan, 1970 and Tibbs and Potter, 1972).

Morgan (1970) summarized water chemistry data accumulated since 1929. (Table 2). Unfortunately, the methods and techniques utilized in obtaining the analyses varied, and comparison of the data to determine nutrient changes are tenuous. However, our synthesized data of nutrient inputs from sewage systems and land use activities in the Upper Flathead drainage support the trends of increased ammonia and nitrate nitrogen and ortho-phosphate concentrations.

Specific studies of contamination of lake waters are limited. Torangeau (1968) analyzed members of the aquatic biota for pesticide

Table 2

Flathead Lake Water Chemistry

Forty Year Span

	Howard 1929	Potter & Baker 1961	Morgan 1967	Morgan 1968	Morgan 1969	
Aluminum	9.3	*	0.04	0.04	0.03	mg/l
Bicarbonate	-	10.2–85.7	80.0	80.0	75.0	mg/l
Carbonate	20.5	4.0	10.0	7.5	5.0	mg/l
Carbon Dioxide	2.0	0.0	Trace	0.0**	0.0	mg/l
Chloride	0.32	*	0.50	1.00	0.75	mg/l
Iron Total	0.02	0.60	0.10	0.05	0.05	mg/l
Ammonia-Nitrogen	0.13	0.01	0.32	0.25	0.23	mg/l
Nitrite-Nitrogen	-	Trace	Trace	Trace	Trace	mg/l
Nitrate-Nitrogen	Trace	0.05	0.16	0.12**	0.19	mg/l
Dissolved Oxygen	8.0	11.0	10.3	10.8	10.5	mg/l
pH	8.4	8.0	8.3–8.7	8.2–8.7**	8.3–8.8	units
Phosphate-Ortho	Trace	0.20	0.16	0.11	0.15	mg/l
Silicate	8.2	*	5.0	4.7	4.5	mg/l
Sulfate	24.9	*	5.5	7.0	6.8	mg/l

* Not determined by researcher
** Denotes extremes not included

7-8-68	detection of Titanium - Deep Water
7-25-68	detection of Titanium - Flathead River & Mouth of Flathead
11-1-68	detection of Acid pollution - Flathead River & Mouth of Flathead pH dropped from 8.7 to 6.6

content. He found significant quantities in certain species of higher trophic levels. Bauer (1969) and Hern (1970) measured coliform bacteria numbers as indices of sewage contamination. Bauer found that coliform bacteria concentrations obtained near the shores often exceed the state standard for the lake (50 coliforms per 100 ml). Samples taken away from the shoreline were consistently low, and no fecal coliforms were found. "Septic tank seepage into the lake was shown to be capable of producing total coliform populations greatly exceeding the state standard." Hern's conclusions were very similar to those stated by Bauer. Coliform bacteria data has also been obtained from 1966 to the present by the Lake County Sanitarian personnel (Robertson, unpublished data). This data also found high coliform concentrations near the shores, with late August, early September being the period of highest contamination.

This summer, 1200 homes surrounding Flathead Lake were tested to determine potential faulty sewage systems. Florescent dye was flushed into the sewage systems and boat and aerial observations were made to watch for the appearance of the dye in Flathead Lake. 67 sewage systems were tentatively determined to be faulty by the appearance of dye or local algal blooms.

Bauer (1969) and Gagiermien (pers. comm.) have shown that severe bacterial contamination can occur from septic tank seepage while these same systems show a negative response to the dye test. The fact that over 5% of the systems tested were believed faulty from either the presence of the dye or algal blooms, undoubtably indicates a more severe bacterial contamination problem.

More information exists for Flathead Lake than for any other body of water in the drainage. Yet the status of water quality and possible changes in trophic status are unclear. Morgan (1970) maintained that the 50 meter level of the lake marks a point of permanent stratification. He argues that no mixing occurs below this level, thereby creating a nutrient sink. If this be the case, the lake could remain relatively unproductive despite high nutrient input. Other researchers demur at this hypothesis, because nutrient differences between shallow and deep water samples are not great. Vertical temperature profiles as determined by Hanzel (1970) support the belief that the lake is dimictic.

Flathead Lake is obviously receiving larger amounts of nutrients of all categories at present than in the recent past. Whether or not the lake has experienced a significant increase in productivity remains unanswered.

Quantitative plankton data are not available for comparison with work done by Bjork (1967), Morgan (1968, 1971), Ivory (in progress) or Potter (in progress). No quantitative data are available for periphyton or higher aquatic plants.

Morgan (1970) concluded that Flathead Lake is in an oligotrophic state. Ivory (in progress) found phytoplankton productivity in shallow Polson Bay of the lake to be very low this summer. Potter (pers. comm.) contends, however, that the productivity of the 20 to 40 meter zone of the lake is rather high for an oligotrophic lake. Morgan found the species Tabellaria quadrisepta to occur at a maximum population of 186,180 per liter at the 30 meter level. His computer analysis showed this organism to be a cold water form requiring high nutrient levels. Morgan also correlated coliform bacteria with species of blue-green algae appearing in the lake.

Estimates of increased nutrient inputs from cultural practices are reason for some alarm and vigilance. Potter's research and the continuing sampling program done by the Montana Fish and Game Department should enable detection of any significant increase in plankton productivity within the lake. It would be very useful, however, if the State Department of Health and Environmental Sciences could place a sampling station on the Flathead River near Bigfork. This station is needed to assess the amounts and fluctuations of nutrients entering the lake from the river. Analyses should include ammonia and organic nitrogen, and total phosphorus, besides those tests already being conducted by the Kalispell office. Chemical analysis of discharges from the Bigfork sewage facility, and samples from the Swan River as it enters the lake might also be useful to complete information of nutrient inputs from the upper Flathead drainage system.

Schuster (1971) has determined that hydrocarbon wastes from outboard engines are capable of supporting microbial populations without the addition of other nutrients. Motorboat wastes have been estimated to contribute a significant amount of organic carbon during the summer months. While boat use in the open waters of the lakes is deemed low, extensive use occurs in protected bays and shoreline areas. Pollution control devices appear warranted on boats utilizing Flathead Lake.

The bacteriological monitoring program, discussed elsewhere in this report, is particularly desirable for Flathead Lake.

Water Quality Studies on Streams and Tributaries on Flathead Lake

Stream flow data have been gathered by the U.S.G.S. in conjunction with Montana agencies for over 50 years in the Flathead drainage. A complete list of gauging stations, periods of operations, and drainage areas is listed in Appendix III. Stations currently in operation and those to be operable in the near future are also listed.

Water quality data were first gathered and analyzed by the U.S. Geological Survey on the Flathead River in 1949 (U.S.G.S., 1951). Yearly samples from rivers in the drainage began in 1963, but were discontinued in 1970. Most samples were from the three forks and mainstem of the Flathead River. Monthly sampling for chemical parameters of the Flathead River at Columbia Falls (1949, 1963-1967), Bigfork (1969-70) and Polson (1969-70) are available. Daily water temperature data (max-min) are available for some locations. Water chemistry grab samples are available for all three forks of the Flathead River, and also for Ashley Creek.

The State Board of Health conducted physical, chemical and biological surveys of the Flathead and Whitefish Rivers and Ashley Creek for purposes of stream classification (Spindler and Brink, 1957). Information on the biota collected from this study, though considered inconclusive because of difficulties with small sample sizes, represents the only published biological survey of the drainages into Flathead Lake. A summary of their findings is included as follows:

Summary:

1. "In many cases, the number of bottom samples collected from streams of the Flathead River Study Areas is considered inadequate, however, other determinations (chemical and bacteriological) substantiate the conclusions drawn from biological results."
2. "The Flathead River constitutes a relatively soft to moderately hard source of water for domestic use, however, sewage pollution from Whitefish via the Stillwater River, Ashley Creek, and Polson render the entire stream from Kalispell to its confluence with the Clark Fork, unsafe for use as a Class A water supply."
3. "A short section of the Flathead adjacent to Kalispell and the river from its confluence with the Little Bitterroot to the Clark Fork is unsafe for any use except agricultural and industrial."
4. "The Flathead River from Kalispell to about ten miles above Flathead Lake and from Polson to the Clark Fork is considered potentially dangerous from a bacterial standpoint for use by swimmers, anglers, hunters and trappers."

5. "Bottom collections indicate an adverse effect on the Flathead River by the discharge of inadequately treated sewage from Kalispell via Ashley Creek and from Polson with recovery to normal stream conditions retarded by silt loading from agricultural practices particularly along the Little Bitterroot River."

6. "Sewage discharge from Whitefish exerts an adverse effect upon the Whitefish River from the point of discharge to its confluence with the Stillwater River. The Whitefish River and Lake above town constitutes a very good water supply requiring only chlorination, however, the river below town is unsafe for any use except agricultural and industrial."

7. "Near septic conditions of gross pollution exist in Ashley Creek below the discharge of inadequately treated sewage from Kalispell and MPN coliform organism analyses indicate that the creek below this point is extremely unsafe for any use."

U. S. Geological Survey data for Ashley Creek (1969-70) reveal that statement seven above is still an accurate description of lower Ashley Creek. To our knowledge, these summary statements are all still valid with the exception of statement two. Data of Bauer (1969) and Hern (1970) indicate that the main portion of Flathead Lake is a safe Class A water supply. Utilization of lake water near the shores, however, may not be safe.

The Forest Service has taken samples for chemical analyses on the North, Middle, and South Forks of the Flathead River plus samples taken below their junction at Columbia Falls (Delk, unpublished data). Insecticide and herbicide tests were run on these same drainages and revealed a total absence of these chemicals in the Upper Flathead drainage at Columbia Falls (Delk, unpublished data).

A Forest Service study on stream temperature variability and fluctuations due to logging was conducted on a tributary of the North Fork in 1969-1970 (Casey, 1971). Representatives of the aquatic flora and fauna have been gathered in many drainages by Sonstelie, but data is presently in unavailable form (Sonstelie, personal communication, 1972).

The Montana Fish and Game Department has done extensive sampling of lakes and streams to determine present and potential fish populations. Water samples are generally tested for dissolved oxygen, standard conductance, total alkalinity, pH, and water temperatures. Data are available for many of the minor tributaries and lakes, with particular emphasis on Flathead River and Lake, and Lake Mary Ronan. Of particular interest to us are samples taken from the South Fork, below Hungry Horse Dam. These samples have shown reservoir-caused modification of physical and chemical characteristics (Hanzel, 1965, 1967; Domrose, 1971). A summary of studies completed to date are as follows:

Survey of Fish and Game Studies on Flathead Drainage

Containing Water Quality Data

Project Number	Period of Survey	Area Surveyed	Data Obtained
F-7-R-13 Job III	7/1/63-6/30/64	Flathead River and tributaries	Survey of cutthroat trout and dolly varden, water chemistry*
F-7-R-15 Job III	1/1/65-6/30/66	Flathead River and tributaries	Survey of cutthroat trout and dolly varden, water chemistry
F-7-R-18 Job I	4/1/68-3/31/69	Small lakes, Lake Mary Ronan	Gill net surveys, water chemistry
F-7-R-19 Job 1-a	4/1/69-3/31/70	Small lakes and streams, Lake Mary Ronan	Gill net surveys, water chemistry
F-7-R-19 Job I-b	4/1/69-3/31/70	Flathead River and tributaries, Lake Mary Ronan	Water chemistry
F-7-R-20 Job I-a	4/17/70-3/31/71	Lake Mary Ronan, other lakes	Water chemistry
F-7-R-20 Job I-b	4/1/70-3/31/71	Lake Mary Ronan, other lakes	Water chemistry, dissolved oxygen profiles

*Water chemistry here means the following analyses were made: pH, temperatures, alkalinity, standard conductance, dissolved oxygen

Project Number	Period of Survey	Area Surveyed	Data Obtained
F-32-R-4 Job No. I	7/1/67-3/31/68	Mission Mountain lakes, Jewel Basin Lakes	Gill net surveys, water chemistry
F-32-R-5 Job No. I	3/31/68-4/1/69	Lake survey - Swan, Middle & North Fork Flathead River drainages	Gill net surveys, water chemistry
F-32-R-6 Job I-a	7/1/69-6/30/70	Lake survey-Stillwater and South Fork of Flathead River drainages	Gill net survey, water chemistry
F-33-R-2 Job No. I	7/1/67-6/30/68	Flathead Lake	Gill net survey, plankton, benthos, water chemistry
F-33-R-3 Job No. I	11/67 - 8/69	Flathead Lake	Gill net survey plankton, water chemistry
F-33-R-4 Job No. I-b	7/1/69-12/70	Flathead Lake	Surface plankton, light penetration, water chemistry
F-33-R-5 Job II-a	10/70-9/71	Flathead Lake	Water chemistry, plankton production, and physical characteristics

Several water quality studies have been conducted in Glacier National Park, by park personnel. Wasem (1968) reports chemical analyses for most of the larger drainages in the park, including a eutrophication study of McDonald Valley. Chemical analysis of many water supply systems (surface and ground water) was done for the park by the State Board of Health in 1971 (Glacier National Park, unpublished data).

Studies in Progress

Evaluation of Present Methods Employed for Monitoring Water Quality

The State Board of Health and Environmental Sciences (hereinafter referred to as "The State") currently has 20 water quality monitoring stations located in the upper Flathead drainage. A list of chemical and physical parameters being measured, methods, and general locations of these sampling stations is included on the following pages. Exact locations are recorded in Appendix V. These sites are sampled once a month, beginning July 1972, and are expected to be sampled for a two year period.

Throughout, methods discussed are compared to "Standard Methods, 13th Edition." The analyses being used by the State should therefore provide quite an exact assessment of the chemical parameters measured. The questions to be addressed in this report are 1) whether or not these tests provide adequate indices for measuring or detecting eutrophication of the Flathead drainage system, and 2) whether deleterious results from land management practices and waste disposal methods can be detected by this monitoring system.

The terms "oligotrophic" and "eutrophic" are often used - and misused in discussing water quality. Hutchinson (1969) defines the criteria for such classifications. He states, "It is now apparent that we should think not of oligotrophic or eutrophic water types, but of lakes and their drainage basins and sediments as forming oligotrophic or eutrophic systems ... By a eutrophic system, I mean one in which the potential concentration of nutrients is high; there may happen to be an extremely low concentration in the water because the whole supply at the amount is locked up somewhere else in the system - in sediments or in the bodies of organisms. This is exemplified by what evidently happens in many shallow lakes in the temperate zone." Also, lakes of high nutrient content can be low in productivity because some limiting factor (e.g. C, N, P, Fe, Mo, Mg, Na) may be lacking (Ibid).

Kalispell Water Quality Tests

Test	Method
pH	Portable meter (with buffers)
Temperature[1]	Thermometer
Turbidity	Hach Kit
Alkalinity, P.M. Total	Standard Methods, titration
Acidity	Standard Methods, titration
Hardness	EDTA titration
Solids (all types)[1]	drying, combustion, weighing
Dissolved Oxygen	Winkler-Alkaline Iodide Azide Mod.
B.O.D.$_5$	Standard Methods
C.O.D.	Standard Methods
Nitrate Nitrogen[2]	Phenoldisulfonic acid
Nitrite Nitrogen[2]	Standard Methods
Total (dissolved) Phosphorus	Persulfate Method
Ortho (dissolved) Phosphorus	Stannous chloride
Total Coliform	Membrane Filter Technique
Fecal Coliform	Membrane Filter Technique
Chlorides	Argentometric method
Sulfides[2]	Titrimetric (Iodine) Method
Sulfate	Gravimetric
Conductivity	Wheatstone Bridge

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[1] No chemicals needed.

Hooper (1969) discusses physical, chemical, and biological parameters that serve as eutrophication indices. Indices applicable to the Flathead drainage will be discussed below. He states that though plant nutrients are widely accepted indices of eutrophication, correlations and relationships of these chemicals to productivity are not as yet clear.

Hooper cites Beeton (1965) as having successfully correlated increasing concentrations of sulfate, chloride, sodium, potassium, calcium and total dissolved solids with a progressing eutrophication of the St. Lawrence Great Lakes. These chemicals are generally conceded to provide relatively stable indices, their values fluctuating less, seasonally, than is the case with various forms of inorganic nitrogen and phosphorus. Hooper considers total phosphorus to provide the best index for measuring allochthonous phosphorus inputs. Inorganic nitrogen, specifically nitrates, are often used as an index. However, Hooper feels that nitrogen fixation, nitrification and denitrification abilities of certain blue-green algae and bacteria prevent this measurement from being used as an accurate index.

Nitrogen and phosphorus content does, however, correlate with excessive growths of algae and other aquatic plants. Lee (1970) cites Sawyer et al (1945) and Vollenweider (1968) as having shown that when ammonia and nitrate nitrogen concentrations are equal or greater than 0.3 mg/l N, and orthophosphate content equals or is greater than 0.1 mg/l P, high productivity is likely. Unfortunately, such criteria are good only "after the fact", and indicators with some predictive utility must be used before the algal blooms appear.

We conclude then that the measurements for sulfates, chlorides, and total dissolved solids being carried out by the State represent the most important indices for information and prediction with reference to the aquatic milieu. U.S.G.S. data are available for comparison at the Columbia

Falls station. Data obtained in the periods from 1949-50, and 1963-67 are available.

For water chemistry information, an additional station on the Flathead River near Bigfork would be of use in determining the chemical characteristics of Flathead River water as it flows into Flathead Lake, and for comparison with the Columbia Falls station.

It is predicted that monthly sampling on the South Fork below Hungry Horse Dam will produce data, the "artificial variations of which merely indicate associated variations in discharge from the dam. This has been indicated by previous Fish and Game Department studies (Hanzel 1965; Domrose, 1971). Data should be correlated and compared with Fish and Game Department's monitoring stations and water release data from Hungry Horse Dam.

Baseline water quality data are lacking for surface waters in the drainage for comparison with information currently being gathered. Stations are expected to be receiving varying degrees of pollution from different sources as explained by the following chart:

Station Number	Name	Pollution Sources Expected to be Degrading Water	Previous [illegible]
1,2,3.	Spring Creek N.E. of Kalispell	Agriculture, individual sewage systems*	None
4,5,6	Stillwater River	Agriculture individual sewage systems	None
7	Whitefish River near Kalispell	Municipal sewage, agriculture, individual sewage systems	None
8	Whitefish River below Whitefish	Municipal sewage, agriculture, individual sewage systems	None
9	Whitefish River below Whitefish Lake	Water quality of Whitefish Lake discharge, individual sewage systems	County Sanitarian (1952)
10	Ashley Creek above Kalispell	Agriculture, individual sewage systems	State Board of Health (1957); U.S.G.S. 1969-1970
11	Ashley Creek below Kalispell	Kalispell Municipal Sewage, and as in station 10	State Board of Health (1957); U.S.G.S. 1969-1970
12	Ashley Creek below Kalispell	Kalispell Municipal sewage, and as in station 10	None
13	North Fork of Flathead River	Timber management practices, roads	None
14	Middle Fork Flathead River	Individual sewage systems, Lake McDonald Lodge sewage	U.S.G.S. grab samples; Fish and Game Surveys
15	South Fork Flathead River	Modification of physical and chemical characteristics by Hungry Horse Dam	U.S.G.S. grab samples; Fish and Game surveys
16	Flathead River at Columbia Falls	Composite effects of stations 13-15 + increased individual sewage systems	U.S.G.S. 1949-50, 1963-67, Fish and Game surveys
17	Swan River below Swan Lake	Water quality of Swan Lake discharge, individual sewage systems	None
18	Swan River above Swan Lake	Timber management practices, roads and animal wastes	None
19	Swift (Whitefish) Creek	Timber management practices, roads	None
20	Lazy Creek	Timber management practices, roads, animal wastes	None

*These stations were originally designed for monitoring effluent from a feedlot that has since ceased operation. The possibility exists that the lot may be [illegible]

The State is at present fully occupied with existing stations and samples given the limitations of existing personnel and facilities. However, it is believed that two periods during the year may be peak pollution periods; if so, these deserve more frequent observation. Spring run-off usually carries a natural high sediment load. Sedimentation is believed to be increased from logging production and presence of forest roads, and agricultural practices (including livestock wastes). Low flow periods of late August - September are predicted to carry high nutrient loads. At that time, dilution of municipal sewage is greatly reduced. Maximum tourist use is believed to overload existing septic tank systems. Summer home systems are also in maximum use. Irrigation return flows to ground waters are maximum during this period (Columbia Inter Agency Committee, 1957), and ground water discharge to surface waters is believed to constitute a considerable percentage of total stream flow at this time. For these reasons, monthly sampling may not be sufficient to determine the extent of water quality degradation which may occur during these periods.

Existing stations have obvious limitations toward assessing the extent of pollution from specific sources. This is because of the number of potential different pollution sources which may exist above each station. The stations above and below the sewage outfall of Kalispell should give adequate assessment of nutrient input and BOD that will be useful in determining the improvement of water quality by the proposed secondary treatment plant. Oxygen depletion, however, can only be assessed by using the 24-hour oxygen analysis procedure.

Evaluation of Information Being Gathered by Other Agencies Indirectly Involved in Water Quality Monitoring

The Montana Fish and Game Department, Kalispell Office, has gathered baseline water quality data for many lakes and streams in the drainage as part of their fish management program. Water physical and chemical properties measured include temperature, pH, alkalinity, dissolved oxygen, and specific conductance.

A list of major studies in progress or yet to be published is as follows:

Fish and Game Dept. Studies in Progress

Project No.	Completion Date	Area of Study	Analyses
F-7-R-21 Job no. I-a	6/30/72	Lake and stream survey	Physical, chemical and biological data
F-7-R-21 Job no. I-b	6/30/72	Lake Mary Ronan, Swan River tributaries, Flathead River	water chemistry
F-33-R-7 Job no. I-a	6/30/73	Flathead Lake	gill net surveys
F-33-R-7 Job no. I-b	6/30/73	Flathead Lake	age and growth analyses of fish
F-33-R-7 Job no. I-c	6/30/73	Flathead Lake	techniques for sampling kokanee populations
F-33-R-7 Job no. II-a	6/30/73	Flathead Lake	water chemistry, plankton production and physical characteristics

Fish and Game Water Physical and Chemical Data
Methods in Use at Present

Temperature: (continuous monitoring of Flathead)
Foxbourough or Taylor 30 day continuous recorder

pH: Bechman pH meter, line operated with regulated voltage

Alkalinity: Methyl orange-phenol-phenolthalian titration

Dissolved Oxygen: Modified Winkler method (Sodium azide standardized with thiopotassium dichromate)

Standard Conductance: Battery operated conductance meter (Allied Industrial Co.)

Dissolved oxygen measurements, specifically vertical series sampling, are reported as a useful eutrophication index. Hooper (1969) considers the change in the shape of the oxygen curve and the change in hypolimnetic oxygen deficit as adequate indices of changes caused by enrichment, especially for deep stratified lakes. He states that oxygen budget data and oxygen curves appear relatively stable with changes other than enrichment. Hooper cites Edmondson et al (1956) in stating that a relationship exists between hypolimnetic oxygen deficits and phosphate concentrations, indicating that this index might correlate with phosphate enrichment.

The Fish and Game Department's studies of Lake Mary Ronan and Flathead Lake have provided data on oxygen distribution in these lakes. Yearly comparisons are warranted to detect potential nutrient enrichment.

Populations of fishes, particularly the west-slope cutthroat trout and Dolly Varden, are useful indicators of clean water. Reproductive success of these fishes indicates a stream with high oxygen content, stable low temperatures, and low concentrations of suspended sediments. Such criteria are useful in determining effects of logging and roads in forested areas of the drainage.

Conversely, population changes and the appearance of catostomids (suckers) as dominant species provide well known indications of pollution (e.g., low oxygen content, thermal increases, high suspended sediment content, and the like) in the dynamics of fish population changes. Hence, populations and species composition serve as indices, whether the fishes themselves are directly or indirectly affected by ecosystem modification. The sensitivity of fishes to minor sources of pollution is questionable, however, they represent one of the easiest biological indicators to assess. Compilation of existing data and yearly evaluation are warranted.

The University of Montana Biological Station at Yellow Bay has a number of studies in progress that will provide further baseline data on Flathead Lake and on the North, Middle and South Forks of the Flathead River along with the mainstem from Columbia Falls to the lake.

Mr. Thomas Ivory, a Ph.D. candidate at the University of Utah, is finishing a three-year study on phytoplankton productivity in Polson Bay. Population characteristics along with productivity measurements of phytoplankton and corresponding physical and chemical parameters of the bay will be reported. His thesis should be finished within the year.

Ivory's methodologies in measuring productivity deserve some comment. The standard light and dark bottle technique, utilizing evolution of oxygen as a measurement of productivity often did not produce statistically significant results. (Arithmetic difference between the two oxygen contents often less than 0.15 mg/l). Therefore, the more sensitive technique utilizing uptake of ^{14}C was employed. Productivity of Polson Bay was often found so low that the volume of sample filtered was increased from 50 ml to 200 ml to produce more accurate results.

David Potter, a University of Montana Ph.D. candidate, is beginning a three-year study of zooplankton of Flathead Lake that will include sediment analysis at the Flathead River delta. This analysis should provide a historical reference of the rate of sedimentation along with an historical record of crustacean populations. Such information will complement existing knowledge of the chemical and physical parameters of the lake and reveal cultural impact on sedimentation rates.

Jack Stanford, a University of Utah Ph.D. candidate, is beginning a three-year study of the benthos, especially plecoptera of the Flathead River. This information will determine what affect Hungry Horse Dam has had on changes in species composition and population dynamics of aquatic insects on the South Fork and main stem of the Flathead River. This knowledge should give an indication of the indirect influences of the dam on fish populations.

The Flathead National Forest is conducting a limited program of water quality analysis as part of their wild and scenic river study. Grab samples are collected and analyzed for: pH, specific conductance, total coliform bacteria, dissolved oxygen, turbidity, alkalinity, total hardness, and suspended solids. Methods used are those of the HACH DR-EL Field Kit and HACH 1060A Lab Turbidity Meter. Fecal coliform culturing is done by the Kalispell General Hospital.

Mr. Christopher Hunter has initiated a study of the increasing eutrophication of Tally Lake. Dr. A. R. Gaufin has worked for many years on lakes and streams in the drainage, focusing his efforts especially upon ecology of the stoneflies, but also devoting considerable attention to the limnology of Flathead Lake itself.

Drs. G. W. Prescott and W. C. Vineyard have collaborated for some years on a monographic treatment of the desmids of North America, deriving much of their material from the Flathead drainage.

Population

An estimated 47,000 permanent residents live within the study area (U.S. Census Bureau, 1970). A majority of the population is located north of Flathead Lake in the Kalispell Valley. Personal observation of the Canadian drainage area leads this investigator to believe that the permanent population is less than 200 residents. Most of the Flathead County's 39,460 persons reside within the study area, with approximately 7,000 in the Lake County and 50 persons residing in the Missoula County sections of the study area. The portions of Powell and Lewis and Clark counties which are within a wilderness area lack a permanent population, and Lincoln County has fewer than 100 persons living within the study area.

Thomas et al, (1968), projects the 1990 population of Flathead County to be about 50,600. A corresponding projected increase for the total study area would be about 59,400. However, by 1970, Thomas' estimate was 5% low in its predictions, and at Flathead County's present growth rate, (19.7% growth between 1960-1970), a population of about 56,500 would exist in 1990 for Flathead County and approximately 67,500 persons living full time in the study area. This later projection is felt to be more valid and perhaps even low. While specific data are lacking, the rate of subdivision development is extremely rapid. It appears that people are moving into the drainage simply because of the high quality environment to be found therein. Certainly there appears to be no economic incentives for moving into the area. However, by September 1972, the Kalispell Chamber of Commerce had received more specific inquiries for moving to Kalispell than the total mail inquiries received for all reasons (visiting, conventions, etc.) in 1969 (Kalispell Chamber of Commerce, written communication). We therefore suggest that a predicted population growth of 20% in the next 10 years is highly probable.

Economics

Agriculture, forestry and wood products, tourism, and aluminum reduction comprise the basis for the economy of the Flathead drainage (U.S. Census Bureau, 1970). Per capita income is around $2,500 (U.S. Census Bureau, 1970). Present trends indicate no dramatic change will occur in the next ten years to either stimulate or retard present economic conditions. Agriculture and forest products can be expected to be relatively stable, with continued growth in the tourism industry.

Unemployment fluctuates seasonally, becoming lower during the summer tourist season, but considerably higher than the national average. Data for Flathead County have shown the unemployment rate to be over seven percent for the last four years. For the first five months in 1972, the State Employment Service reported an unemployment rate of 11.3 percent. The employment service stated that such a rate may continue for some time (*Missoulian* 1972).

Figures for other counties have not been obtained, but are believed to be similar to Flathead County. No large industry other than forest products exists within the remainder of the study area.

Water Use

Flathead County reports that only ten towns in the county have either public or privately owned water systems. One percent of rural farms and 39% of rural non-farms have a public water supply. The remainder of the population draws its water from individual wells or other sources (Thomas, et al, 1968).

Lake County has a similar situation, with 37% of the total population on community water systems (U.S.D.A. Committee for Rural Development, Lake Co., 1972). Private wells are assumed to be the source of water for persons living in other counties of the study area.

The larger communities, with the exception of Kalispell, draw upon surface water for their municipal water supply (Pacific Northwest River Basins Commission, 1971, Appendix XI).

Groundwater is usually obtained from two of the six types of aquifers, the deep artesian and flood plain gravel aquifers (Konizeski, et al, 1968).

While total domestic, agricultural and industrial water use is not known, an estimated 7 billion gallons per year is utilized in the Kalispell Valley alone. This estimate excludes surface waters or springs utilized for irrigation or livestock. Konizeski (1968) reported the following estimates for groundwater use in 1966:

Aquifer	Gallons per year
Deep artesian	1,585,000,000
Shallow artesian	ca. 4,000,000
Outwash sand & gravel	101,000,000
Floodplain gravel	3,430,000,000
Sand aquifer	15,000,000
Total	5,135,000,000

The largest consumer of water is the Anaconda Aluminum Reduction Plant at Columbia Falls, which consumes 3.6 billion gallons per year from groundwater sources (ibid).

Community use of water is projected to almost double in the area, from 7.2 million gallons per day in 1970 to about 13.2 million gallons per day in 2020 (Pacific Northwest River Basins Commission, Appendix XI, 1971).

Kalispell's water supply is primarily from the flood plain gravel aquifer. Most of Kalispell's suburban areas utilize this source. Konizeski found evidence to show that this aquifer could become badly polluted from industrial and domestic sewage.

Chemical Constituents of Natural Waters

No naturally occurring rivers and lakes contain "pure" water, and the Flathead drainage is no exception. Naturally occurring dissolved and suspended elements, ions and organic compounds are to be found in all waters. Data on these natural levels are unknown for most "impurities" in the Flathead drainage; however, inferences can be made from the oligotrophic status of Flathead Lake. The geologic, climatologic and biologic factors that contribute nutrients, salts, and organic materials are such that in the past productivity of the lake was very low.

Geologically, the Flathead basin lakes are very young, perhaps only 12,000 years old. The bedrock that composes the mountains and subsoil is basically Ravalli Quartzite and Peigan limestone. These rocks contribute minute amounts of heavy metals, elements and ions such as calcium, potassium magnesium, sodium chloride, sulfate, phosphate and other ions necessary for plant growth. The bedrock, and particularly the Peigan limestone, is soluble to the extent that the salts content of the Flathead River causes the water to be considered "moderately hard."

Precipitation in the form of rain or snow contribute dissolved substances that have been recognized as important to lake and stream productivity (Gambell and Fisher 1964). Calcium, sodium, sulfate chloride, ammonia, nitrate and some nitrite and phosphorus are contributed to surface waters from this source. These substances originate from the soil and sea, or as in the case of nitrite, from man-caused air pollution. Junge (1958) correlated agricultural activity and soil reactions as principal sources for ammonia and nitrate, respectively. McGauhey, Dugan and Porcella (1971) found precipitation in the Lake Tahoe basin to average 0.357 mg/l nitrogen and 0.015 mg/l phosphorus. This concentration of nutrients was higher than that of Lake Tahoe water, and bioassay determinations revealed an increased algal growth reponse to the precipitation. Air pollution from California cities and intensive agriculture west of the basin are believed responsible for the enriched precipitation.

Nutrient content of precipitation in the Flathead drainage has not been determined. Data from Junge (ibid) indicates that the amount of ammonia plus nitrate content of rainwater in the Flathead drainage to be about 0.25 to 0.30 mg/l nitrogen. Organic nitrogen content of rainwater is not known for the area, but McGauhey, Dugan and Porcella (ibid) found the organic nitrogen content of precipitation to be more than total inorganic content.

A comprehensive study of nutrient inputs to the Flathead drainage would not be complete without measurement of the nitrogen and phosphorus content of precipitation.

Terrestrial plant and animal activities significantly affect water chemistry. Photosynthetic and chemosynthetic organisms act as nutrient pumps that result in solute changes in runoff and percolate. Organic materials are formed and carried to surface waters by runoff or groundwater flow. Nitrogen-fixing organisms transform elemental nitrogen to nitrate, which can then be leached to ground and surface waters. Historically, the organic and inorganic inputs from these terrestrial sources must have been low.

The bacterial content of natural waters can be altered by runoff containing soil bacteria and fecal bacteria from terrestrial animals. Prior to the introduction of domesticated animals, slight fecal contamination undoubtedly was usual. Walter and Stuart (1971) investigated the bacteriology of both open and closed (no public access) watersheds near Bozeman, Montana.

They found that the numbers of coliform bacteria and enterococci were higher in the stream closed to public access than in an open watershed. The answer to this phenomenon appeared to be that large populations of wild animals utilized the closed watershed. Hence, pristine waters in such areas in the Flathead drainage such as the Bob Marshall Wilderness and Glacier National Park may be expected naturally to have some fecal bacterial contamination.

Similarly, pristine waters will receive organic and nutrient contributions from wild animal populations.

Effects of Suspended Solids on Aquatic Biota

Suspended solids, measured as turbidity of the water, may be caused by inert substances, such as silt and clay from soil erosion, organic debris from sewage discharges and feedlots, or by living or dead plankton. Combinations of the above causes are common in the study area. Only the physical presence of the particles or degree of opaqueness of the water caused by the above materials, is to be discussed in this section.

All streams in the study area carry or have carried some materials that cause turbidity. Spring runoff from snowmelt causes very high flows. Streams and rivers fill their flood plains and often cut new channels through the plain. The lower Flathead River, below Columbia Falls is an excellent example of this sort. The Middle Fork, southeast of Glacier National Park, is essentially a wild river with no human modifications. Fairly high turbidities recorded on occasion by Delk, Flathead National Forest Hydrologist (1972, unpublished), indicate the extent of natural turbidity.[1]

Duchrow (1970), has reviewed the literature on the effects of turbidity on fish. He states that the cold water fish that feed by sight are prevented from feeding by turbid waters. When the sediment load is very high, sediments can cause abrasion and loss of the protective mucus surface, smother fish eggs, or bury benthic invertebrates and thus remove a form of available food. Wallen (1951, in Duchrow 1970), reported fish killed by high clay turbidities had opercular cavities and gill filaments clogged with clay particles. Such high turbidities seldom occur naturally, but rather they are associated with human activities.

Sediments can absorb light energy, thus raising the water temperature. Duchrow (1970) cites Eschmeyer (1954), Bachman (1958), Casey (1959), Cordone and Pennoyer (1960), and Cordone and Kelley (1961) as reporting changes from cold water species to warm water species or a reduction in size of cold water fish populations from increased turbidities caused by mining or logging practices.

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[1] Note: The 1964 flood has apparently caused the stream beds to have been altered, and natural stabilization may not have yet been completed.

Tarzwell and Gaufin (1962), report that a type of detrimental and synergistic effect may occur when suspended sediments are present in combination with organic materials such as sewage or animal wastes. Turbidity decreases light penetration and limits growth of phytoplankton and other aquatic plants. Available food for herbivores is thus reduced and an amount of dissolved oxygen from photosynthesis is lost. While plant growth is reduced, bacterial action is not affected and mineralized organic materials from this bacterial action are carried for greater distances. Upon sediment settling in reservoirs or lakes, the mineralized products act as fertilizer for plant growth, and troublesome algal blooms may occur far from the source of organic pollution. Ashley Creek below Kalispell might be observed for the above effect.

High amounts of suspended sediments can thus greatly reduce or alter the structure of aquatic systems, reducing the aesthetic qualities of waterways and lowering the economic benefits of cold-water fisheries.

High turbidity is a naturally occurring spring phenomenon in the Flathead drainage. Human activities must obviously have increased suspended sediments; however, data supporting this statement are lacking for the major tributaries of the drainage. Suspected causes of increased turbidity will be discussed in sections evaluating land practices.

The Flood of 1964 - Natural Alteration of Water Quality

Between June 8-10, 1964, an unprecedented flood occurred on the Upper Flathead drainage. The stream gauge at Columbia Falls recorded a height of 22.7 feet with an estimated flow of 176,000 c.f.s. as regulated by Hungry Horse Dam. Damage was estimated at $23,580,000 for the upper Flathead basin, (U.S. Army Corps of Engineers, 1967). The regulation by Hungry Horse Dam is credited with protecting 18,400 acres of land and having prevented $10,000,000 in damages (U.S. Army Corps of Engineers, 1971). For the first time in the history of Hungry Horse Dam, turbid water was observed below the reservoir and turbid water in the South Fork below Hungry Horse was evident for months after the North and Middle Forks cleared (Hanzel, 1965). Turbid water was present in Flathead Lake in late summer and fall, long after the lake usually clears.

No unequivocal data exist concerning the impact of this flood on the biota (there were no University of Montana studies underway on Flathead Lake that year). Hanzel (1965), postulates:

> "The far reaching effects of the flood on aquatic life in the river and lake regions have not been determined. However, the heavy silt load carried into the lake could reduce the plankton and other aquatic life. The tributary streams, heavily scoured bv the flood, may have had heavy losses of resident stream cutthroat."

Stream stabilization may have been greatly affected by this record flood. The Middle Fork, much of which is a wild, unmodified river, has been exceedingly turbid in the spring season since the flood, as Forest Service data indicate, and mud slides have occurred in its tributaries recently (Delk, personal communication, 1972). Effects of this increased turbidity should be studied in comparison with almost identical but stable tributaries.

Rural-Domestic Wastewater

A year-round population of about 27,000 persons is estimated to use private sewage facilities, a large percentage of which are septic tank systems. An influx of tourists and summer residents increase the use of this form of sewage disposal to a year-round equivalent of perhaps 33,000-35,000 persons. Private sewage system usage then is almost double that of municipal sewage system usage within the Flathead drainage. Only one percent of the rural farms and 39% of rural non-farm homes have a public water supply (U.S.D.A., 1972). With continued rural development, septic tank use along with private wells may present health problems and will cause degradation of water quality.

A septic tank of adequate design and size, with a proper drain or absorption field will remove almost all BOD and suspended solids of the sewage for an extended period of time. However, residual solids accumulate in the absorption system and will gradually reduce the system's efficiency. Finally, the drainage from the septic tank will surface at or above the soil surface and/or channel through the soil to a point of free discharge, such as a stream or lake (Daniel, et al, 1971).

Assessment of pollution contributions to surface and ground waters from private sewage systems has been difficult. Two extreme situations may occur: either the system is capable of digesting sewage to mineral components or the system is clogged and discharges raw sewage to surface or ground waters. The former condition is assumed for the majority of the systems operating, however, the fate of the mineralized components especially the nitrogen compounds, is questionable. Hypothetically, under aerobic conditions, organic nitrogen is oxydized to nitrate, and then could be denitrified to elemental nitrogen. Whether denitrification occurs under "normal" (which more often than not may mean "overloaded" or otherwise abused) septic tank systems is very doubtful. McGauhey, et al. (1971). found that seepage from septic tank leaching fields near Lake Tahoe to contain 30 milligrams per liter (mg/l) ammonia, 0.026 mg/l nitrate and 0.010 mg/l nitrite. McGauhey believes that the high concentrations of ammonia were due to the close proximity of the sample site to the drain field, and that "its ultimate conversion to soluble nitrates is certain and can be expected eventually to enrich the lake via a combination of routes":

1. "Movement as soluble nitrogen (nitrates) in ground water directly or through outcropping in surface streams."
2. "Surface wash from decaying vegetation which grew more luxuriant as a result of nitrogen in the ground water."

The time required for these nitrates to appear in surface waters is unknown. If a septic tank drain field is located on a groundwater recharge area, nitrates could readily move into groundwater aquifers. Furthermore, a septic tank system may create or aid groundwater recharge. Assuming that a person utilized 75 gallons of water per day, which is discharged to septic systems, then almost one billion gallons of waterwastes are discharged into systems in the Flathead drainage yearly. A high percentage of this amount is believed to percolate to groundwater aquifers, carrying most, if not all, soluble nitrates from septic tank effluent to groundwater sources.

Groundwater movements vary with the aquifer substrate and have been reported by Konizeski, et al. (1968), to vary from 50 feet per year for the perched gravel aquifer to less than 0.1 feet per year for the deep artesian aquifer in the Kalispell Valley. Hence, the lag time for nitrate input from septic systems is usually measured in years, but the present amount of nitrate-nitrogen being discharged to groundwaters is estimated at 230,000 pounds per year.

The role of the county sanitarian is important in controlling new sources of water quality degradation from individual sewage systems. The sanitarian must have knowledge of soil types, groundwaters, and drainage patterns in determining placement and size of septic systems. Criteria for such systems are included in Appendix V. Reference guides, especially including the "Soil Survey of the Upper Kalispell Valley, and Geology and Groundwater Resources of the Kalispell Valley", are useful to the Flathead County Sanitarian. No such information exists for other areas in the drainage, and it would be exceedingly useful if these categories of information could be compiled for the use of the several counties' sanitarians.

The political situation involving the county sanitarian deserves note. The sanitarian is under the supervision of the county's commissioners who are generally strongly interested in expanding the tax base. That goal is at times at variance with the orderly performance of the sanitarian's duties.

Furthermore, the county sanitarians' salaries are low, making it difficult to hire and retain competent persons.

The rapid suburban development of the drainage is such that the sanitarians' offices can barely keep up with new development, much less inspect potentially faulty systems. Monitoring existing systems occurs only if a complaint is filed, or if other matters bring a problematical situation strongly to the sanitarians' attention.

Systems of adequate capacity and design which are used the year around are probably more efficient than those used only seasonally. An efficient system can remove almost all BOD, but it is doubtful if nutrients, especially nitrates, are prevented from eventually entering ground or surface waters. Groundwater temperatures are reported to be around 50 degrees F (Konizeski et al. 1968), and septic systems provided only with cold well water, such as that available in campgrounds, can be expected to have low BOD removal and no nutrient removal.

Septic system failures, caused by overloading, improper construction, or placement in impermeable soils or on bedrock, cause local serious pollution problems. McGauhey and Winneberger (1965) have set forth the following criteria of septic tank design and maintenance:

"1) Any soil continuously inundated will lose most of its initial infiltrative capacity. In leaching systems, this leads to failure if the system is designed on the basis of initial infiltration rates higher than the ultimate low rate.

2) Maintain an aerobic system by alternate periods of resting and loading on an optimum cycle.

3) Destruction of infiltrative capacity (of the drain field) by construction methods: a) smearing sidewall and bottom surfaces; b) compaction of bottom surface by feet or machinery; c) silting of excavation during the rain. Hence, the infiltrative surface (of the drain field) must be kept as near as possible representative of an internal plane in the undisturbed soil.

4) The entire infiltrative surface should be loaded uniformly and simultaneously.

5) There should be no abrupt change in particle size between trench fill material and infiltrative surface of the soil.

6) The system should provide a maximum of sidewall surface per unit volume of effluent and a minimum of bottom surface.

7) The amount of suspended solids and nutrients in the septic tank effluent should be minimized. A two-compartment septic tank with a screen-protected outflow pipe behind a scum baffle is recommended."

Should a septic system become overloaded and become totally anaerobic, ferrous sulfide is precipitated which can totally clog the infiltrative surface. By not utilizing the system for a time, oxygen can reenter the system, oxydizing the ferrous sulfide to ferric sulfate, which is soluble and can be removed with water.

Size of the septic system should be determined by "the most conservative value for anaerobic clogged infiltrative capacities, "which McGaughey and Winneberger found to be 0.03 feet/day in their test sites.

Annual inspection and biennial pumping of the septic system are suggested.

Proper installation and maintenance of a septic system of adequate size to prevent overloading with annual inspection should prevent direct discharge to surface waters. A bacteriological monitoring program recommended elsewhere in this report would provide a necessary check on irresponsible motel, trailer court, or campground owners. Other specific recommendations have been made under the criticisms of existing legal controls.

A feasibility study and perhaps a pilot project should be undertaken to determine whether areas of high seasonal populations could utilize a seasonal municipal sewage system with spray irrigation facilities. Perhaps such a system could be utilized in conjunction with the locally expanding Christmas tree plantations, forested areas, or croplands.

An alternative plan could involve the construction of concrete vaults which could be pumped regularly and disposed of in a closed lagoon system built at a centralized location. Again, the wastes collected in these vaults could be pumped and disposed of by spray irrigation.

For less populated areas that are unable to install septic systems due to bedrock, impermeable clay or other restrictions, individual sewage systems are available that are essentially no-discharge, closed systems. A number of these systems are available on the market, yet the public is relatively unaware that such systems exist. An educational program on these systems may be beneficial.

Muncipal Sewage Systems

Five public sewer systems exist in the study area serving the communities of Kalispell, Whitefish, Bigfork, Columbia Falls and Polson. In addition, Lake MacDonald Lodge and the Lakeside Air Force Base also have municipal systems. A summary of the types of existing systems and population served is as follows:

Location	Type	Population Capacity	Daily Flow Discharge (million gal/day)	BOD Removal
Kalispell	Primary	18,000	2.25[1]	53.1%[4]
Whitefish	Lagoons	3,936	.29[2]	79.4%[4]
Bigfork	Trickling Filter	200[6]	.08[2]	95%(est.)[6]
Polson	Lagoon	2,400 (est.)	.145[3]	?
Columbia Falls	Aerated lagoon	2,200 (est.)	0.3	95% (potential)[6]
Lakeside Air Force Base	Closed lagoon system	160[5]	none	100%
Lake MacDonald Lodge	Trickling Filter	Seasonal	0.1 (?)	90%

1. Petrini, et al, 1971. Comprehensive Development Plan, Flathead-Kalispell City-Co. Planning Area. 1971. 90 pp.
2. Thomas, et al, 1968. Comprehensive County Water and Sewer Plan.
3. Robertson, Duane, Lake County Sanitation Officer. Personal communication.
4. State Board of Health, Kalispell Office, 1972. Unpublished data.
5. Nunnallee, Dave. State Dept. of Health and Environmental Science, Sanitary Engineer, Personal communication. 1972.
6. Willems, P.E. Chief, Water Quality Bureau, Environmental Sciences Division, State Board of Health & Environmental Sciences. Written communication. 1972.

Our estimate of the permanent population currently utilizing municipal systems is about 20,000. Polson's lagoon system discharges into the Flathead River below Polson, has no direct affect on Flathead Lake, and has not been evaluated in this report.

Recent improvements, or improvements scheduled in the near future are as follows:

Lakeside Air Force Base. Work is underway to seal all joints in the piping system; that should assure no discharge from their 80 acre lagoon system, of three ponds in series.

Columbia Falls. The aerated lagoon-sand filter system is currently being sealed to prevent rapid discharge of untreated sewage into ground waters.

Bigfork. The trickling filter system presently has leakage and drainage problems caused by improper construction. Known defects have been determined by television analysis (Butler, 1967). Litigation is underway to determine liability for repairs.

Kalispell. A secondary treatment plant awaits approval of engineering plans by EPA. The proposed secondary plant, utilizing oxidation towers, secondary clarifiers, and secondary recirculation system, is designed to remove 96% of BOD and 97% of suspended solids.

Lake McDonald - Park Headquarters. A proposed spray irrigation sewage disposal system has been budgeted for fiscal year 1974. Treated sewage will no longer be discharged into Lake McDonald.

Future municipal systems must conform to Montana's non-degradation clause and must be no-discharge, closed systems. (See Brink 1967, Policy Statement 14).

With the installation of secondary treatment at Kalispell, all municipal systems with effluents tributary to the Lake are secondary treatment equivalents. Oxygen depletion of receiving waters should not be a problem but for Ashley Creek during the summer's reduced flow and the Whitefish River during cold periods of the winter.

The 10-20 year plan for new public sewage systems for Flathead County include plans for installations at Rose Crossing, Creston, Mountain Brook, Holt, Echo Lake, Ferndale, and Montford School (Thomas, et al, 1968). Soil conditions and present water contamination indicate that Lakeside is also in need of some form of sewage disposal other than septic tanks.

The Kalispell sewage system produces by far the worst pollution from a single discharge source in the study area. Ashley Creek, which receives the Kalispell sewage effluent, is grossly polluted from the point of sewage plant discharge to the place where the stream empties into the Flathead River. The State Board of Health (Spindler 1957) had this to say of Ashley Creek:

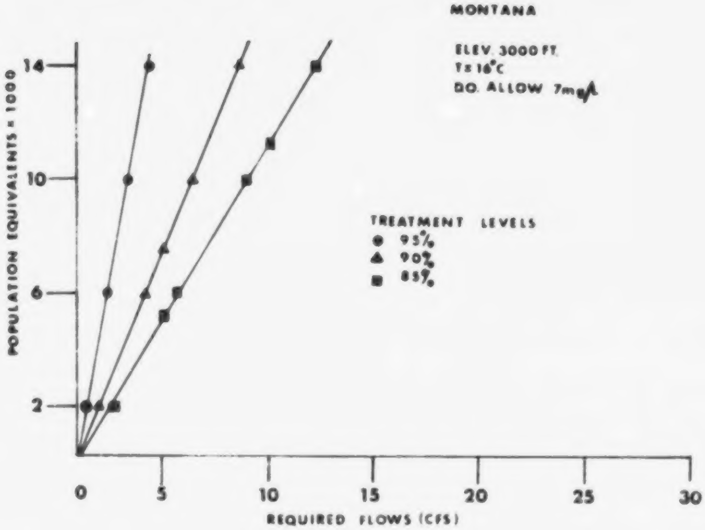
> "Near septic conditions of gross pollution exist in Ashley Creek below the discharge of inadequately-treated sewage from Kalispell and MPN (most probable number) coliform organism analysis indicate that the creek below this point is extremely unsafe for any use."

Though the sewage plant was enlarged in 1959, U.S.G.S. data for 1969-1970 reveal that conditions have not significantly changed.

A secondary sewage facility is pending for Kalispell. The proposed secondary plant, utilizing oxidation towers, secondary clarifiers and a secondary recirculation system is designed to remove 96% of the BOD and 97% of the suspended solids. Whether or not oxygen depletion will then occur in Ashley Creek will depend upon the amount of water in the creek at the time. Ashley Creek water is removed above the sewage plant for irrigation water. U.S.G.S. streamflow data reported "no flow" as a minimum for this creek above Kalispell. The Pacific Northwest River Basins Commission (1971, Appendix XII) calculated minimum flow needs to maintain Montana dissolved oxygen standards criteria in the following graph.

Figure 5

Minimum flow rates in sewage treatment
necessary for conformity with Montana dissolved oxygen criteria



From this graph the study concluded:

"From a brief examination of the above mentioned graph, it was found that only Ashley Creek ..... is the only area ..... in which existing streamflows do not seem sufficient to assimilate projected wastes after treatment." Currently, Ashley Creek is classified an "E" stream below Kalispell and has no specified oxygen criteria (Brink 1967). The above study's criteria would allow for the survival of trout (D.O. = 7 mg/l). It would appear then, that only by preventing the sewage effluent from entering the creek could oxygen levels be maintained suitable for trout. Direct piping to the Flathead River with provisions for spray irrigation has been suggested to solve this problem. The engineering firm that designed the secondary treatment facility that is tentatively to be installed at Kalispell superficially examined this proposal and rejected it because of the costs involved.

Lagoon systems suffer from temperature variations. Eckenfelder and Englande (1970) report that photosynthetic oxygen production and BOD removal rates are greatly modified by temperature variations. Optimum photosynthetic activity is reported at 20 degrees C, with upper and lower limits at 35 degrees C and 3 degrees C, respectively. Freezing of the lagoon surface can reduce light penetration, and a snow-cover can result in a completely anaerobic system. Spring and Fall overturns may also create short-term anaerobic conditions.

Sawyer (1968) and Carpenter et al (1968) concluded that aerated lagoons with short retention times will be very sensitive to temperature change. Vennes and Olson (1970) concluded that the limiting parameter in BOD_5 reduction in an aerated continuous discharge lagoon in North Dakota was available oxygen, while temperatures were of little importance. These authors were reporting on a two-celled series system with a 20 day retention time.

Temperature effects on BOD reduction are minimal on activated sludge and trickling filter processes (Eckenfelder and Englande, 1970).

Processes of nutrient removal by municipal sewage treatment facilities are apparently far more sensitive to temperature changes than is the case with BOD removal. Terashima et al, (1971) found that nitrogen removal (Organic N + ammonia) ceased below 10 degrees C in an activated sludge process. Above that temperature, a relatively stable amount (of 23-24%) was removed. Temperatures of municipal sewage are not available for those systems operating in the drainage, but it can be assumed that temperatures below 10 degrees C (50 degrees F) are common.

The processes that occur in sewage sludge result in the production of a vitamin, biotin, by sewage bacteria. Fillip and Vennes (1970) have correlated biotin production and algae growth. Vennes and Olson (1971) feel that the disappearance of biotin from sewage sludge may be directly related to algal numbers. Further research is needed before any conclusions can be drawn, but methods employed to remove nutrients other than biotin from municipal sewage may be insufficient to reduce algal blooms should this vitamin be found to be a factor enhancing growth.

Water quality data was obtained by the U.S. Geological Survey on Ashley Creek above and below the sewage outfall near Kalispell on four different dates in 1969-70.

Calculations were attempted to determine daily nutrient inputs from the sewage facility. Pounds per day of nitrogen and phosphorus can be calculated assuming the sample is representative of the average nutrient content of the water both above and below the outfall.

The following estimates were obtained:

Date	Net increase in total nitrogen per day (NO_3-N+NO_2-N + OrgN+NH_3-N)	Net increase in total phosphorus per day
7/8/69	884.0 LB	343.8 LB
10/14/69	192.2 LB	109.5 LB
1/13/70	235.3 LB	119.2 LB
4/14/70	87.0 LB	130.8 LB

Assuming that each person contributes about 7 pounds of nitrogen and 2 pounds of phosphorus to sewage facilities yearly, and that 11,000 persons utilizing Kalispell's sewage system per day, then 230 pounds of nitrogen and 60 pounds of phosphorus would enter the system daily. The above erratic data are perhaps the result of incomplete mixing of the sewage effluent with Ashley Creek. Furthermore, the volume of sewage effluent has daily cyclic patterns, and it appears that most samples were taken during midmorning, a peak discharge period.

It is safe to assume that the existing primary treatment plant removes almost no nutrients. We estimate, therefore, that 70,000 pounds of nitrogen and 20,000 pounds of phosphorus are being discharged into Ashley Creek from this facility yearly.

After Kalispell, the most inefficient treatment of sewage occurs at the Whitefish sewage facility. The system consists of two lagoons in series. A nonaerated lagoon system is subject to severe fluctuations in efficiency caused by climatic changes. The State Board of Health and Environmental Sciences determined BOD_5 efficiency of the lagoons on May 12, 1972 to be 79.4% removal. The efficiency probably improved during the warm summer months but may drop well below 50% during the cold months of winter. Gordon (1971) reports that the addition of sewage effluent, especially that containing high nitrate and phosphate levels, increased microbial activity of the receiving waters at zero degrees centigrade and markedly reduced dissolved oxygen levels. Therefore, the Whitefish River may experience serious oxygen depletion problems below the Whitefish sewage outfall during the coldest parts of winter.

Nonaerated lagoons do not appear suitable for use in climates such as western Montana where the temperatures average below freezing for almost 4 months out of the year. The Whitefish system should be modified at least to an aerated system. Vennes and Olson (1970) found that such a system in North Dakota with a minimum of a 20-day retention time would not suffer from temperature fluctuations, but is dependent only upon available oxygen. A comparable system, then, should solve Whitefish's oxygen depletion problems.

Kalispell and Whitefish represent the only municipalities where oxygen depletion is a problem. Nutrient contributions, however, are relatively uncontrolled, and will remain a problem even when Kalispell and Whitefish install systems equivalent to secondary treatment. Low annual temperatures apparently limit even the low nutrient removal potential of these systems. We therefore suggest a 10% removal of nitrogen and phosphorus is a better estimate than the 30% removal we previously indicated. Annual use of municipal sewage facilities in the upper Flathead drainage (excluding Polson) is currently estimated at 17,000. We estimate, therefore, about 110,000 pounds of nitrogen and 30,000 pounds of phosphorus are discharged to surface waters of the Flathead drainage yearly.

Further improvement of existing or planned municipal systems to enhance water quality by removing these nutrients, while desirable, is questionable. Nutrient inputs from municipal sewage are relatively low compared with certain other land practices in the Flathead drainage.

Conversely, the systems represent point discharges of high nutrient concentrations that can be easily controlled. Continued population growth within the municipalities will eventually necessitate tertiary treatment. The present disposal of sewage effluent is a waste of a valuable agricultural resource, as Parizek, et al. (1967), determined by utilizing sewage effluent to spray irrigate crops and woodlands. Yields for certain crops could be tripled by utilizing the effluent for irrigation waters. Unlike conditions prevailing in the Pennsylvania State study, however, it is doubtful that spray irrigation could be utilized here year around.

While it is a well documented fact that the installation of tertiary treatment facilities could lower the productivity of receiving waters, the expense of tertiary treatment might be more beneficially utilized by controlling nutrient inputs from other, more deleterious sources of water degradation. These sources in the Flathead drainage include agriculture, and livestock. Individual sewage systems are estimated to contribute almost twice as much nitrogen to the drainage.

Livestock wastes

The agricultural census of 1969 reported 36,641 cattle on 539 farms and the sale of 18,439 swine from 77 farms in Flathead County (Bureau of Census 1971). Five commercial feed lots with the annual capacity of about 45,000 head were reported in 1972, (U.S.D.A. Committee for Rural Development, Flathead Co., 1972). The animals are rather evenly dispersed over the Kalispell Valley and lower parts of the drainage. Total confinement feeding is employed for a large portion of the swine production. Animal wastes from this procedure are pumped into manure spreaders. Dumping of this waste is not known but may occur.

Feedlots have caused considerable water pollution in local streams in the past, particularly in the area around Spring Creek northeast of Kalispell. The feedlot presenting the greatest problems is not operating at present. Only three feedlots are known to be in operation at the present time (Nunnallee, personal communication). The State Board of Health and Environmental Sciences in Helena is currently working on potential control measures for feedlots across the state.

Using Flathead County's livestock estimates as a minimum number of animals on the study area, total waste figures can be calculated from data accumulated by Robbins, Howells, and Kriz (1971). Cattle within Flathead County produce an estimated 1,282 tons of solid wastes and 412 tons of liquid wastes daily (1969 livestock figures). Assuming market size of swine to be about 225 pounds, 160 tons of wet manure is produced daily by swine in Flathead County. Another 35 tons of manure per day is estimated to be produced by horses in the county. The organic carbon, nitrogen, and phosphorus contents of these wastes are of particular concern to water quality.

Oxygen depletion and nutrient enrichment from these sources are believed very significant in the drainage. Control of this source of pollutants is generally lacking in the drainage. Monitoring systems to detect such pollution are absent except for those stations operated by the State. Local problems exist; it is apparent as discussed elsewhere that cattle in the Lake Mary Ronan drainage are rapidly degrading the water quality of that lake. Cattle are also known to have direct access to Flathead Lake in some areas, (Robertson, personal communication).

Robbins, Howells, and Kriz (1971) have determined nitrogen and phosphate (PO_4) inputs from cattle and swine to surface waters for certain drainages in North Carolina. These values can be used to estimate nutrient inputs for livestock in the Flathead drainage.

	LB/day/animal		Total inputs for all animals/yr	
	Nitrogen	Phosphate	Nitrogen	Phosphate
Cattle (37,000 head)				
Direct discharge	0.034	0.027	460,000	365,000
Land spreading	0.008	0.003	108,000	40,000
Swine (19,000 head)				
Direct discharge	0.032	0.017	222,000	118,000
Land spreading	0.002	0.001	14,000	7,000

Table 3. Estimates of nutrients from livestock (Nitrogen and Phosphate LB/day/animal data from Howells, et al., 1971).

Minimum nutrient inputs can then be estimated by adding the calculated wastes of cattle and swine which assume that all manure was disposed by land spreading techniques. Estimates of 122,000 pounds of nitrogen and 47,000 pounds of phosphates (15,300 pounds of phosphorus) are obtained. Maximum estimates obtained by assuming direct discharge are 682,000 pounds of nitrogen and 483,000 pounds of phosphates (160,000 pounds of phosphorous). The actual amount of nutrient enrichment caused by livestock wastes in the Flathead drainage is between these estimates, and probably closer to the higher figures. Manure spreading is not common practice for cattle wastes in the Flathead drainage. Furthermore, the soil is frozen for about a three-month period and livestock wastes accumulate on the soil surface or on snow. Spring runoff on winter cattle range is believed to be highly enriched with livestock wastes. We estimate, then, that nutrient enrichment from animal wastes to surface waters is about half of the maximum estimate, or over 300,000 pounds of nitrogen and about 80,000 pounds of phosphorous per year.

No data are available to determine nutrient enrichment of ground waters from livestock wastes. No problems of phosphorus enrichment are expected, but nitrate enrichment may be significant. Konizeski, et al. (1968), reported high nitrate levels in certain perched aquifers in the Kalispell valley that may in part be due to livestock wastes. A ground water study of the area should include assessment of potential nitrogen enrichment from livestock wastes.

Recommendations to control this source of water pollution have been made by Robbins, Howell and Kriz (1971) and are as follows:

North Carolina State University Study (1971)

Conclusions

1. "The natural pollution load on streams draining agricultural basins free of farm animals can be appreciable during periods of rainfall and runoff and should be taken into consideration in water quality management."
2. "Except for nitrate penetration into the groundwater at one site, pollution indices for land drainage from waste spreading and control watersheds paralleled stream hydrographs with extended dragout

on cessation of surface runoff. The rise in indices with runoff was roughly proportional to increase in flow of stream over base flow. Where nitrate had entered the groundwater, concentrations in stream were inversely proportional to flow, peaking under dry-weather conditions."

3. "The extent of water pollution caused by farm animal production units is more dependent on production and waste management practices than on the volume of wastes involved."

4. "The land provides a natural treatment system for animal wastes and land spreading is a very effective means to prevent water pollution. Even in cases where the disposal sites are poorly located or managed or where pastured animals have access to streams, the amount of pollutants (natural plus animal wastes) which reach streams is a very small proportion (less than 10 percent) of the potential from the animal wastes deposited in the watersheds. Proper land spreading can reduce pollutants entering streams by more than 99 percent. Criteria for this purpose is provided."

5. "Differences in watershed characteristics such as slope, soil permeability, surface culture, drainage pattern, degree of erosion and other factors are of great significance in determining the quality of streams draining agricultural basins. This emphasizes the importance of good soil and water conservation practices to minimize the movement of wastes into streams."

6. "Although estimating equations developed from this study with temperature, number of animals and rate of land runoff as independent variables and pollution parameters as dependent variables do not have general applicability, predictive relationships held quite well for many sets of data collected over short periods of time showing promise that estimating equations to serve the needs of water quality management can be developed with a more detailed and longer term study, particularly if the equations include effects of more hydrological variables."

7. "The use of anaerobic lagoons as the sole means for treatment of animal wastes is an unsatisfactory practice in areas where rainfall exceeds evaporation. Even when lagoons provide more capacity per animal than USDA and other recommended standards recommended, effluents still exceed raw domestic sewage in strength. Although the amount of surface discharge and resulting stream pollution from lagoons can be lessened by reducing the amount of wash-water, diverting runoff from surrounding areas, and locating lagoons to prevent surface and subsurface inflow, at least intermittent surface discharge is assured unless deep seepage is excessive."

8. "The practice of dumping fresh animal wastes directly into streams causes severe pollution. Swine and dairy production units are the principle sources in North Carolina. Although the water quality downstream from a discharge point is largely predictable from

characterization of fresh wastes, the quality varies erratically with flow rate depending on the amount of solids carried by the water. The large pollution load imposed on a stream by a direct discharge operation overshadows the load from surrounding pastures or other land disposal operations. The streams are generally more polluted in the summer and pollution increases with surface runoff."

9. "Simple regression analyses support the conclusion that total organic carbon can be used as a rapid and reliable measurement of pollution from animal wastes and for the estimation of other pollution indices."

10. "Antibiotics and toxic metals in animal feeds apparently interfere with the BOD_5 analysis of animal wastes at levels above 60 mg/l, necessitating the concurrent use of TOC (or COD) for the estimation of degradable organics and oxygen demand at BOD_5 levels above 60 mg/l."

11. "The state of the art of animal waste management for pollution control is primitive, indeed. Many questions remain with regard to animal waste characterization, related water quality studies, and the proper design of lagoons and other waste treatment facilities used in conjunction with or independent of land spreading."

Preventive measures are necessary to prevent massive contamination by livestock wastes during spring runoff. Cattle and swine overwinter in relatively small areas in lower portions of the valley. Collection of manure for later land spreading may be possible and may be an economical alternative for inorganic fertilizers.

All cattle should be immediately removed from the Lake Mary Ronan drainage until some workable solution can be found to keep the cattle out of the lake and feeder streams.

Fencing livestock away from streams may be warranted in certain areas.

Large numbers of livestock should not be allowed on land serving as major groundwater recharge areas, especially during the late spring, early summer period, until studies have been conducted to determine the extent of nutrient enrichment from livestock wastes to groundwater supplies.

Farming Practices

The majority of the lands in the drainage now sustaining some form of agricultural use are found in the Kalispell Valley. 82,522 acres of harvested cropland were reported in Flathead County during 1969 (Bureau of Census, 1971). Of this cropland, about 17,000 acres were wheat, 22,500 acres of other small grains, and about 40,000 acres of hay. Only about 15,000 acres of this cropland were irrigated.

Commercial fertilizer was applied to over 44,000 acres at the average rate of 189 pounds per acre, or 4,175 tons annually (ibid). Assuming the average content of fertilizer to contain 33% nitrogen and 20% P_2O_5, then about 2,500,000 pounds of nitrogen and 660,000 pounds of phosphorus are added yearly to the soil on these 44,000 acres. In fact, the amount of fertilizers used and number of acres fertilized have increased since 1969, making these estimates low.

Agricultural data for other counties in the study area are not available as figures can be found summarized only for counties, not for portions of counties. Farming also occurs in the part of Flathead County that is excluded from the study area, making the previously stated figures for Flathead County slightly inaccurate.

No agriculture or livestock was observed by Seastedt in the Canadian part of the study area. Powell and Lewis and Clark Counties are in the Bob Marshall Wilderness Area and receive only pack-horse use. The Swan Valley in Lake and Missoula Counties has been described "essentially nonagricultural" by the Bureau of Reclamation (1959), however, some hay is grown and grazing occurs at least during the warmer seasons of the year. Cherry orchards cover about 1,100 acres around Flathead Lake of which about 700 acres are irrigated, (U.S.D.A. Committee for Rural Development, Lake County, 1972).

The number of farms in Flathead County has dropped from 1,701 farms in 1940 to 825 by 1969 (Bureau of Census 1941, 1971). The Bureau of Census (1971) has reported that from 1964 through 1969, 77,000 acres of farm land were lost to other land classification types. Subdivision to ranchettes, summer homes, and suburban developments may be presumed to have gained a considerable portion of this acreage.

Acreage under irrigation in Flathead County has increased from 8,000 to 28,000 acres in the last 25 years. Continued growth at this rate would result in 90,000 acres under irrigation by the year 2000. Estimates for irrigation for the entire drainage area are only slightly higher than these figures.

Irrigation, in principle, must supply enough water for transevaporation requirements of the crop and to leach from the subsoil any excess build-up of salts remaining from the application of irrigation waters and fertilizers. Rhoads and Bernstein (1971) summarize the change in solute content as follows:

> "When irrigation waters are reduced in volume by evapotranspiration, sparingly soluble salts present in the waters tend to precipitate. At the same time, soil minerals are being weathered and are releasing soluble salts. Soil mineral surfaces are charged, so that ions are absorbed. As penetrating waters equilibrate with the soil, an exchange of ions between the water and the soil can occur, so that specific ion composition of the soil water may change as the water moves through the soil. Salts are also added to soils as fertilizers and soil amendments, and these are solubilized to varying extents and may then enter into the exchange and precipitation reactions. Finally, other chemicals added to control plant pests and diseases may dissolve in the soil water and modify the water properties.
>
> Thus, the water penetrating the soil is modified in its solute content by evapotranspirational loss of part of the water, by various precipitation and soil solubilization reactions, and by the introduction of fertilizers and soil amendments and pest-regulating chemicals."

The Soil Conservation Service and Montana State University County Extension Offices are in charge of instructing and advising farmers on proper irrigation methods. According to the Soil Conservation Service, Kalispell Office, the major problem with present irrigation practices involves the application of insufficient water for proper crop growth.

It is assumed, then, that return flows are minimal for the amount of irrigation waters applied.

No return flows to surface waters are known to occur above Flathead Lake. Some drainage from irrigation canals is believed to enter the south end of Flathead Lake. In 1969, 21,565 acre-feet of water were used for irrigation purposes in Flathead County (Bureau of Census, 1971). Return flows to ground waters are estimated to be less than 50% of the total water used for irrigation. (Calculated from Pacific Northwest Interagency Committee, 1957).

No methods are employed to prevent ground water degradation from the solute content of return flows. By the year 2000, the irrigation needs of the Kalispell Valley are estimated to be of the order of 293,000 acre-feet of water per year. (Pacific Northwest Interagency Committee, 1957). At the time of these calculations, sprinkler systems were not considered on a full scale basis, so that the estimate is probably high. However, over 100,000 acre-feet per year of return flows to ground water supplies should be anticipated by the year 2000.

Biggar and Corey (1969) have accumulated and summarized the data of many investigators. The literature contains many similar interactions and characteristics of soil solute properties that appear applicable to the Flathead drainage.

Biggar and Corey state, "Precipitation from the atmosphere (or by irrigation) is disposed of by 1) surface runoff; 2) ground water runoff (interflow); 3) deep percolation; 4) storage; and 5) evaporation and transpiration. The first three of these can, and do, contribute to eutrophication by providing pathways of nutrient movement to lakes and streams."

When nutrients percolate to the ground water, their movement to lakes and streams is dependent on ground water movement. Yet mixing of soil solutes with ground water and their subsequent movements are extremely complex and variable depending on the substrate and other factors. Biggar and Corey summarize: "Therefore, it is not safe to assume that nutrients derived from percolating waters will be diluted by the entire ground water mass prior to discharge into a lake."

Biggar and Corey state: "Runoff waters usually contain very little soluble inorganic nitrogen. In fact, the nitrate contents of runoff waters are usually lower than the average nitrate content of rain water. The first rain that falls sweeps most of the nitrate from the air and carries it into the soil."

"The relative concentrations of soluble phosphorus in surface runoff and soil percolates are the reverse of the nitrogen system. If phosphorus fertilizers were applied to the soil surface . . . the concentration of phosphorus in the runoff water might range up to a few tenths of a milligram per liter. In the water that percolates through the soil, the soluble phosphorus concentration is usually very low because the phosphorus precipitates in the subsoil. Therefore, most of the soluble phosphorus should reach the waterways via surface runoff."

"Nitrate is completely soluble in the soil solution and moves with it. Thus the soil percolates generally contain more nitrate than do surface waters. This nitrate eventually reaches the waterways unless the water emerges in a marsh, where it may be absorbed by the vegetation or reduced to gaseous nitrogen."

The movement of nitrates and phosphorus through the soil has been studied by numerous investigators, all in apparent agreement. Scalf, et al. (1968), found that the nitrate ion does not readily absorb but moves freely through aquifers, and there appears to be little denitrification occurring in saturated soils. Parizek, et al. (1967), found that phosphorus concentrations were reduced 99% during passage of sewage effluent through only one foot of soil.

Biggar and Corey cite Bertrand (1966) as having determined that in the great plains area, with an average of 20 inches of precipitation, about 18.8 inches are lost by evaporation and transpiration, 1 inch as surface runoff and 0.2 inches as percolate.

The Kalispell valley has about a 15 inch annual rainfall. Rainfall is believed to be more evenly distributed than in the plains with more of the percentage of precipitation falling during the nongrowing months. This might indicate a higher percentage of surface flow and percolate, but supporting data are lacking. If this be the case, however, estimates utilized from studies under conditions of lesser rainfall, or from areas where the percentage of precipitation occurring during nongrowing months is less will result in underestimates of nutrient percolation to ground waters.

To calcualte nutrient loss to surface runoff and ground waters is difficult at best. Lipman and Conybeare (1936) estimated nutrient loss in soils to erosion and leaching and found an average (and remarkably high) value of 52.0 pounds per acre per year of nitrogen and 12.17 pounds per acre per year of phosphorus lost to surface and ground waters. More recently Sawyer (1947) estimated the average loss of 6 pounds per acre per year of nitrogen and .062 pounds per acre per year of phosphorus to certain lakes in Wisconsin. Erickson and Ellis (1971) found that an average value for nitrogen and phosphorus losses from fertilized, non-irrigated farm lands of clay-loam soils to be about 10 and 0.1 pounds per acre per year, respectively. These farms applied about 140 pounds of fertilizer per acre per year. These investigators also estimated the amount of nitrogen fixed from the atmosphere to be 20 pounds per acre per year.

Irrigation greatly increases the amount of percolate and nutrient leaching. Sylvester and Seabloom (1962) determined nutrient loss on irrigated lands in the Yakima Basin of Washington. Sixty-eight pounds of nitrogen and 1.0 pound of phosphorus were estimated to be leached from an acre of irrigated, fertilized farm land to surface waters. Other values obtained were 33 pounds of nitrogen and 1.3 pounds of phosphorus per acre per year.

Assuming all irrigated lands in the Flathead drainage also to be fertilized, then estimates for nutrient inputs to surface waters can be calculated for the Flathead drainage (Table 4).

Table 4. Estimates of nutrient loss to surface waters from agricultural practices.

Agricultural Practice	Acres	Nitrogen Loss Lb/ac/yr	Phosphorus Loss Lb/ac/yr	Total N Loss Lb/yr	Total P Loss Lb/yr
Nonfertilized, nonirrigated cropland	53,500	6.0[1]	0.062[1]	321,000	3,317
Fertilized, non-irrigated cropland	14,000	10.0[2]	0.1[2]	140,000	1,400
Fertilized, irrigated cropland	15,000	33.0[3]	1.0[3]	495,000	15,000
Fertilized, irrigated pasture	15,000	33.0[3]	1.0[3]	495,000	15,000
Totals	97,500			1,451,000	34,717

1. From Sawyer (1947)
2. From Erickson and Ellis (1971)
3. Most conservative estimates of Sylvester and Seabloom (1962)

We estimate, then, that over 1,400,000 pounds of nitrogen and over 34,000 pounds of phosphates are contributed to surface waters from cropland and irrigated cropland.

Utilization of fairly similar estimates of nutrient loss from non-irrigated nonfertilized lands and nonirrigated fertilized lands may seem unreasonable. However, from the preceding discussion it is noted that phosphorus losses are largely due to surface runoff. Therefore, fertilization would obviously cause an increase in phosphorus content if surface runoff remains constant. However, increased nitrogen in the form of nitrates will percolate into the soils, where the lack of percolation waters will prevent excess leaching. Hence, it appears that nitrogen losses to surface waters are more dependent upon irrigation than upon fertilization.

Should the Kalispell valley eventually have 100,000 acres under fertilization and irrigation, the drainage may be enriched by an estimated 3,300,000 pounds of nitrogen and 100,000 pounds of phosphates yearly!

Proper land management will prevent surface runoff, reducing phosphorus levels somewhat, but will increase subsurface flow, and therefore probably increase nitrate levels further. It may be impossible, then, to control nitrogen inputs, but to maintain phosphorus levels below concentrations where it remains a limiting factor.

The conclusions of Zwerman and others (1971) are therefore recommended here to encourage proper agricultural methods from excessively enriching surface runoff and which might limit nitrogen leaching.

"Long term hay rotations produce the most stable soil physical conditions, which result in the lowest losses of water, soil, and plant nutrients from the land surface."

"By avoiding applications of nitrogen fertilizer in months when crop uptake is low and deep seepage of water is high (October-May) and by restricting the quantity applied to just meet crop requirements, leaching losses of nitrate can be kept to a tolerable level."

"Manure has been demonstrated to have a very beneficial effect on reducing surface runoff. This property is particularly important with respect to limiting phosphorus runoff. Manure may be a good substitute for considerable amounts of fertilizer nitrogen and phosphorus."

Irrigation waters should be applied as sparingly as possible utilizing sprinkler systems to help prevent surface return flows to waterways.

Rhoades and Bernstein (1971) suggest the use of ammonium-nitrogen fertilizer to reduce nitrate inputs to ground waters. While the ammonium will be nitrified with time, plant utilization may lessen nitrate leaching.

Irrigation return flows will be discharging an estimated 140 cfs (year-round average) to ground waters should irrigated acreage reach its potential in the Kalispell valley. Specific studies of 1) the chemical constituents of return flows; and 2) ground water interactions with surface waters are warranted to assess this pollution source.

Subdivision Activity

The Department of Revenue reports that over 68,000 acres of Flathead County have been assessed as suburban small tracts (Tomlinson, 1972). This figure represents approximately 9.2% of the privately owned lands in the county.

There has been an alarming growth of subdivision activity in Montana and especially in the study area over the last decade. Subdivisions which were approved in Montana in 1961 numbered 13, whereas the estimate for 1972 is 130 (Ibid). However, Tomlinson considers even these figures to be only a poor indicator of what is happening with land transactions across the state. The regulations governing land transactions include: 1) the filing of plats; 2) zoning, and 3) sanitary restriction.

Tomlinson states, "Mounting control seemingly has not stemmed the increase in activity, but has instead resulted in more widely practiced illegal subdivision by developers. As speculation increases and land prices rise, the motivating forces at work make this activity all the more lucrative."

"Application of the Environmental Impact Statement requirement has created for the developer a high risk-low return situation. If by subjecting the development to public scrutiny, the development is rejected, the publicity might drastically reduce the value of the ground."

It can be assumed that the developer who knows or suspects that his land would not qualify for removal of sanitary restrictions for individual sewage systems is likely to engage in illegal and unknown subdivision. Hence, all of the known suburban tracts may not pose as severe a threat to water quality as those that go unrecorded. Finally, the unknowing buyer may fail in his attempt to obtain a septic tank permit and may then install a system illegally.

The State Board of Health and Environmental Sciences has the authority to approve water and sewage facilities for subdivision of land into parcels of less than five acres. (Statutory Authority 69-5003). A summary of legal controls and regulations, and a form copy of the Environmental Impact statement which must be submitted is included in Appendix VI. With respect to private sanitary facilities, parcels of land larger than five acres are not regulated by the State, but these still must meet the county sanitarian's requirements for water and sewage facilities.

Water quality degradation caused by rural subdivision development involves increased nutrients to ground and surface waters. Increased BOD demand and fecal bacterial contamination of surface waters result from systems that have failed, were improperly installed, have inadequate capacities or drain fields, or by direct discharge. Improper land management practices around streams and lakes, including: 1) stream channelization or modification; 2) removal of stream overstory; 3) surface and ground water enrichment from lawn fertilization, and 4) weed and pest control contaminants, are causes of thermal, chemical and biological changes in streams and lakes.

Subdivisions and Water Quality

A two-day field survey was conducted with Dr. Richard Konizeski, hydrologist, and members of the Montana Department of Natural Resources and conservation field study team who are currently conducting a resource inventory of an area between Bigfork and Echo Lake. Dr. Konizeski demonstrated the complexity of the soil substrate, subsurface deposits and bedrock formations for this area north of Bigfork. The complexity and diversity of the subsurface deposits make the standardized criteria for sewage disposal facilities and distances from wells and surface waters for sewage drain fields or pit privies totally unacceptable for maintaining water quality.

The following facts were also revealed during the field survey:

1) The rate of subdivision growth greatly exceeds known estimates and is proceeding without sufficient regulation, zoning, or any form of planning.

2) Developers are selling land unseen and are misleading purchasers concerning the availability of water supplies and the ability of the land to be used for individual sewage disposal.

3) Extensive subdivision activity is occurring in aquifer recharge areas. Extensive road construction, housing and other cultural activies may alter the quality and quantity of ground water.

4) Total development of the Kettle lakes area, as presently planned, will speed eutrophication of those lakes unless collective sewage systems are installed.

5) Subdivision development on flood plains is occurring which is totally incompatible with the flood plain concept.

The field survey, along with discussions with W. O. Aikin and David Nunnallee, sanitary engineers for the State Board of Health and Environmental Sciences, have allowed the investigators to be able more critically to examine the state regulations for water and sewage facilities for subdivisions. In general, state controls and regulations are not explicit enough for areas of complex geologic and hydrologic morphology, nor does it appear that these regulations were designed in anticipation of such intensive subdivision activity as is occurring in the Flathead drainage.

State regulations governing subdivision development are presented in Appendix VI. We submit a critique of these regulations as they apply to the Flathead drainage.

Title 69-5002 Section 149 limits regulatory authority to parcels of less than 5 acres. Authority should be expanded to all subdivision activity (the division of a piece of land into two or more parcels). Whether this regulatory authority should be handled by the state or delegated to a more local authority is discussed below.

Title 69-5003 Section 150 in part states, "No building or shelter which necessitates supplying water or sewage or waste disposal facilities for persons shall be erected until the sanitary restriction has been removed or modified. Enforcement of this requirement has been totally lacking. The public is unaware of the requirement and subdividers are known to pass this responsibility by contract to the individual owner. In some instances the land is sold to the unwary buyer without informing him of this condition either verbally or by contract.

Recommendations:

1) The public must become aware of the sanitary restriction regulation. Advertising of land for sale should plainly stipulate (not in fine print) that the parcel has or has not had the sanitary restriction removed.

2) Building permits and septic tank permits should not be issued unless the owner has valid proof of the removal of sanitary restrictions.

3) Certain geographical or geological areas within the drainage including, but not limited to, bedrock outcroppings, ground water recharge areas, clay and lime-cemented fill, are unsuitable for septic tank systems. These areas should be mapped and classified "not for subdivision" unless public water and sewage treatment facilities are provided by the subdivider. Regulation 51.300 Section 3.5 at present allows the subdivider to pass the responsibility for the removal of sanitary restrictions on to the individual owner. Under the above geologic conditions, the owner is caught with an expensive sewage disposal problem.

Regulation 51.300 Section 5 is felt to be unacceptable due to the complex nature of subsoil characteristics within the Flathead drainage. Section 5.4.6 requires information between ground water and the sewage disposal system. Depending on the intervening substrate, a "safe" distance could constitute a few feet to perhaps hundreds of feet. No "safe" criterion exists should the area be a ground water recharge area or the intervening substrate be sand.

Table I (Section 6.2.2) presents criteria for minimum safe distances between sewage disposal sites and water supplies. For reasons similar to those stated above, such criteria are invalid.

Section 6.1.1 states that "Individual water supply systems shall be constructed to provide an adequate supply of water . . ." Wells are being drilled into bedrock in the drainage that are tapping "old" water. These are aquifers that have virtually no recharge capabilities. Water may be supplied for a period of a few years, but will eventually go dry. Hence, ground water in certain areas of the drainage is literally an unrenewable resource and must be recognized and treated as such.

Section 7.1.1 requires that adequate treatment shall be provided for all sewage and waste water to prevent contamination of surface waters. This criterion apparently rigorous, is blatantly violated within the drainage because:

1) no monitoring system to detect pollution sources exists.
2) enforcement is lacking, mainly because the burden of proof is contingent on #1 above.
3) lack of ground water quality criteria allows for indirect contamination of surface waters.

Section 7.2.2 provides criteria for horizontal distances from sewage disposal sites to surface waters. Supposedly, a minimum of 100 feet from the 50-year flood level of any river or lake and, "a distance of greater than 100 feet . . . may be required in some instances." Mapping of 50-year flood levels is virtually nonexistant for most rivers and lakes in the drainage. It appears this criterion has been more or less modified to known water levels, which have proved grossly inadequate in the Kettle lake area, especially at Echo Lake. Presumably, this criterion serves the double function of preventing pollution from drainage fields from entering surface waters and preventing periodic inundation of septic systems. Again, the complex hydrology and geology of certain areas make such criterion of questionable value.

Section 7.4.1 requires that an adequate number of percolation tests be made to demonstrate the absorptive ability of the soil throughout the sub-division. Dr. Konizeski has commented on the fact that percolation tests could vary greatly, not from acre to acre, but within only a few inches. The layering of lacustrine deposits, gravels, sand and fill is so complex in certain areas that the percolation tests reveal little except infiltration rates at that specific point.

Recreation

Campgrounds, motels and trailer courts accomodate the large number of seasonal visitors traveling through the drainage. Glacier National Park is expected to record over 1,400,000 visitor-days this year. The Flathead National Forest is estimated to sustain about 600,000 visitor-days this year.

Seasonal use of a septic system presents special problems. There is apparently a "lag time" before bacterial organisms reach maximum density for proper BOD removal. Overloads obviously occur in Glacier National Park (Daniel, et al, 1971), and around Flathead Lake (Robertson, personal communication). Low water temperatures found in campground facilities result in low BOD removal rates, slowing the digestive processes and lowering capacities of the septic tank systems. Once a system exceeds its capacity, efficiency rapidly drops with retention time.

Except for Flathead Lake and part of Glacier National Park, no systematic studies of septic tank efficiency (as measured by coliform bacterial cultures) have been made. Furthermore, the absence of coliform bacteria gives no indication of the BOD or nutrient inputs of septic tank effluent.

A survey by University of Montana Biological Station personnel was conducted to determine visitor-days to Flathead Lake, Swan Lake, and Lake Mary Ronan. Data was accumulated from campgrounds, motels, trailer courts and summer homes. Excluding permanent residents, Swan Lake and Lake Mary Ronan each receive about 40,000 visitor-days per year. Flathead Lake is estimated to receive a minimum of 750,000 visitor-days during 1972. Data for other popular recreation lakes, such as Whitefish Lake, Ashley Lake, Tally Lake, and the Kettle lakes have not been accumulated.

It is very safe to estimate that the drainage currently sustains a minimum of 3,000,000 visitor-days per year. The rate of increase in tourism in the past has been estimated at about 5%; but the current rate is believed to be between 8% and 10% per year. State campgrounds, for example, have experienced a 60% increase in visitor use in the three-year period between 1969 and 1971 (Montana Fish and Game Department, unpublished data). At least 80% of the total visitor-days occur within the 90-day period between June 15 and September 15, currently giving the drainage an average daily increase in population of about 26,000 persons during this period. With the exception of Lake McDonald Lodge and a few motels in the cities, the wastes from these visitors are discharged into private sewage facilities, usually septic tank systems.

The following premises are made and control measures suggested:

1) We estimate current seasonal use of the drainage to be above 3,000,000 visitor-days annually; more than 80% of these visitor-days occur between June 15 to September 15.
2) The present rate of increase in tourism is estimated to be between 8 and 10% per year. If that rate remains constant, then by the year 2000 the wastes from tourists will exceed those of the permanent population of the drainage (daily, year-round average).
3) The majority of campgrounds, motels and trailer courts are near or adjacent to waterways.
4) Individual sewage facilities, usually septic tanks, are used to handle most of the wastes of tourists.

5) These sewage systems are inefficient for seasonal use due to the lag time necessary to develop adequate populations of sewage micro-organisms, to overloading, and to low water temperatures in the systems. Nutrient removal, especially removal of nitrates, is estimated to be near zero, with the soluble nutrients eventually discharged to ground or surface waters.

Recommendations:

1) A specific study should be commissioned to determine the efficiency of seasonal septic tank use within the Flathead drainage. BOD removal and nutrient enrichment to surrounding ground and surface waters should be assessed.
2) A monitoring program should be established by the offices of the county sanitarian to assess overloading of existing septic tank systems by utilizing the membrane filter-total coliform bacteria measurement. All existing tourist facilities should be monitored. Late August is believed to be the best time for determining whether overloading does occur.
3) Existing tourist facilities located near areas which experience high population densities during the summer months should install municipal systems or vaults as recommended in the rural-domestic wastewater section.
4) Future tourist developments should install some form of closed system, either vaults or spray irrigation facilities, if the latter are shown to be effective in this region.
5) Future individual summer homes adjacent to surface waters should install one of the variety of closed (no-discharge) systems.

6) Glacier National Park will no doubt eventually establish a quota on the maximum number of visitors allowed within the Park at any one time. This quota, of course, must not exceed the maximum capacity of sewage facilities.

7) Federal, state and private campgrounds and parks should utilize chemical toilets. Pumping and disposal into closed lagoons and/or spray irrigation is warranted. The Federal and State campground and park facilities should take the lead in developing no discharge sewage systems.

8) All existing tourist facilities should be required to have their septic tanks pumped yearly.

Problems of Growth of Tourism and Subdivision Activity

Tourism and subdivision activity could be considered to express a negative synergism on land use and water quality in the Flathead drainage. While both activities are rapidly increasing, subdivision activity results in less public access for an ever-increasing number of tourists. The end result is overcrowded campgrounds and parks causing soil erosion, overloaded septic system, and not very satisfying recreational activities.

The land and water can only withstand a certain limit of human use before the natural ecosystem is unalterably destroyed. The present lack of planning and management has lowered the human carrying capacity from the potential limits, and certain waterways of the drainage are showing acute symptoms of eutrophication caused by cultural enrichment.

The ultimate cause of the Flathead drainage's environmental problems is continued rapid, unplanned growth. Responsible officials should recognize and deal with this cause and not merely with the symptoms of growth.

Legislative Needs

Greenbelt planning and land purchase by State and Federal agencies are urgently needed to provide protection to flood plains and other lands adjacent to waterways. Unless such action is taken, these areas are doomed to become areas of high subdivision activity. It is a well known fact that once the public is deprived of access to waterways, their concern for the quality of these waters rapidly diminishes. Such areas are also warranted to relieve population pressure on existing areas of public access.

Whether the State of Montana will enact the strict legislation adequate to protect the Flathead drainage may be questioned. The environmental problems are of concern to certain areas of the state and would probably not receive support or funding from the less-developed ranching counties. Furthermore, any legislation to be effective must have monitoring and enforcement provisions. The personnel and facilities of the State Board of Health and Environmental Sciences at Kalispell should be doubled to meet existing duties and responsibilities. Any increase in regulatory authority should correspond to an increase in personnel - a dubious eventuality in light of the State's economic status.

These problems of development could perhaps be resolved at the county level. We say "perhaps" because up until now county governments have shown little desire to assume the role of a regulatory authority. Flathead County, by far the largest portion of the study area and containing the most developed areas of the drainage, has approved county-wide zoning and planning. However, the zoning board is still in infancy and with few powers. Before the board could adopt strict zoning, monitoring, and enforcement policies, a comprehensive plan must be completed. The plan is perhaps two years from completion. In the meantime, the county could pass interim zoning regulations and regulate subdivision development. To date there has been little interest shown in this approach.

The State must recognize the dynamic interrelationships between surface and ground water supplies. Water quality criteria must be established for ground water. Surface water quality cannot be maintained in the Flathead drainage unless the progressive enrichment of ground water supplies is controlled.

Forest Management

Timber in the drainage began to be harvested for commercial sale in the 1880's. The Great Northern Railway was extended into the area in 1891 expanding local markets. The first major sawmill was at Somers and the Whitefish, Stillwater, Flathead and Swan Rivers were used extensively to float logs to the mills. Deadhead logs found in these rivers recall that period of water use. Clear-cutting began in earnest in 1953 (Flathead National Forest 1972).

No data have been obtained for annual cutting in the Canadian portion of the area. Personal observation revealed thick stands of lodgepole pine covering much of the Canadian drainage. Large burns in the early 1900's may have produced this condition. Limited cutting was observed on the flood plain and lower slopes of the Canadian drainage. The U.S.D.A. Committee for Rural Development (1972) reports that about 1,500,000 acres are utilized for commercial timber in Flathead County. It should be noted that actually 93%, or 3,084,268 acres of Flathead County is forested; however, Glacier National Park, specially classified federal and state lands, and areas of non-commercial timber lower commercial acreage considerably (see Figure 6).

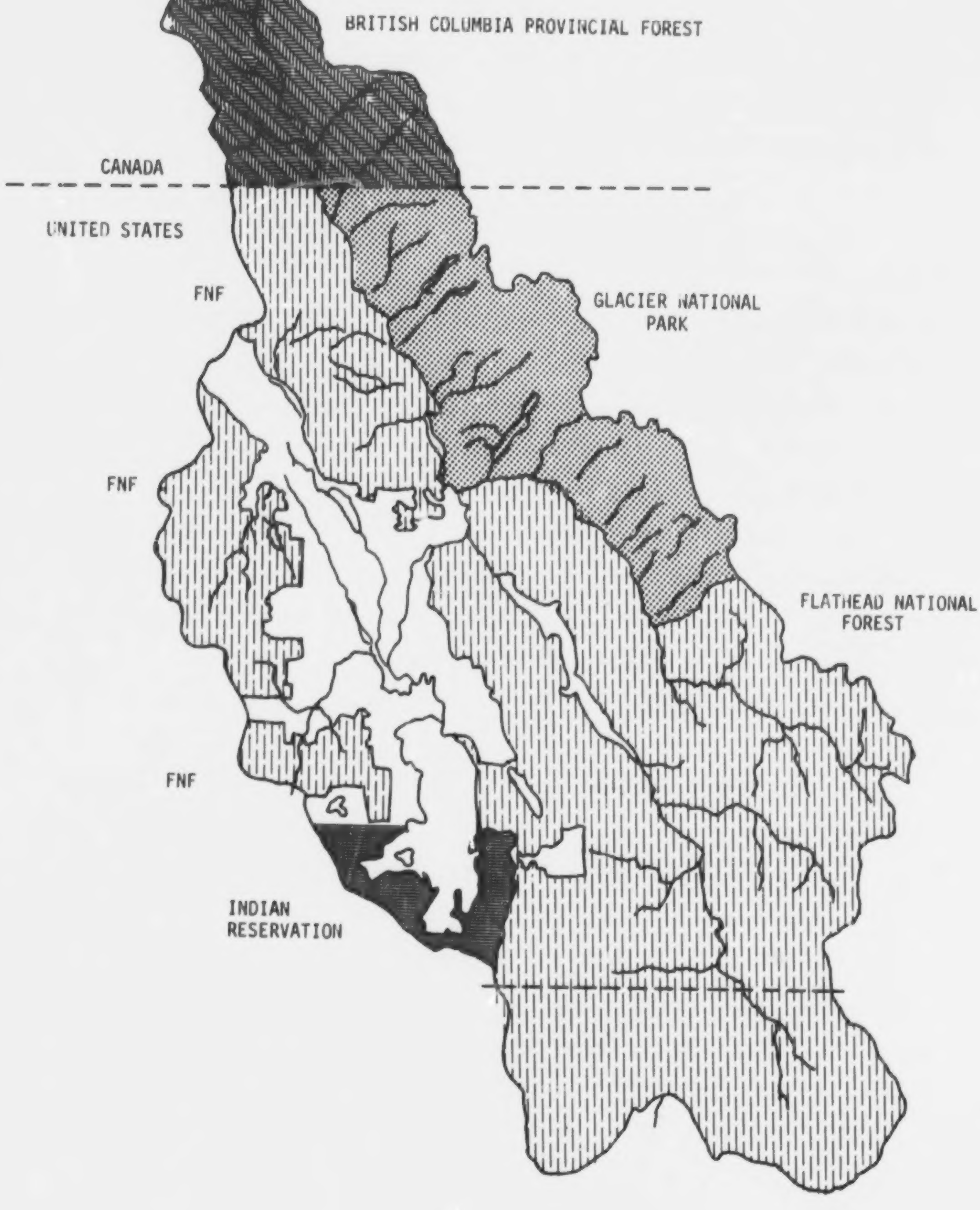
Flathead National Forest lands in the Missoula County part of the study area, account for about 184,000 acres of the estimated total of 262,400 acres within the study area. The State of Montana and Burlington Northern (Glacier Park Company) also have large holdings in the area.

Lake County has about 100,000 acres of Flathead National Forest within its boundaries. Tribal lands, state, corporate and private lands account for 325,224 acres of commercial timber, most of which appear to be in the study area.

Powell and Lewis and Clark Counties, parts of the Bob Marshall Wilderness

FLATHEAD DRAINAGE - FEDERAL LANDS

Figure 6


BRITISH COLUMBIA PROVINCIAL FOREST
CANADA
UNITED STATES
FNF
GLACIER NATIONAL PARK
FNF
FLATHEAD NATIONAL FOREST
FNF
INDIAN RESERVATION

have never been extensively logged. No figures are available for Lincoln County.

Data on some of the varying aspects of federal forest management activities in the Flathead drainage have been obtained (Table 5).

Table 5. Management activities of the Flathead National Forest[1].

Management Practice	Acres Involved			
	Fiscal Year 1970	Fiscal Year 1971	Fiscal Year 1972	Future
Reforestation				
Dozer piling and site preparation	8,519	5,290	5,880	6,300 to 7,100
Broadcast burning	—	284	--	500 to 1,000
Planting	370	841	1,599	1,000
Seeding	1,988	3,879	2,364	2,000
Natural Regeneration	1,921	2,458	3,759	5,900 to 8,500
Thinning				
Pre-commercial	3,624	8,302	6,074	6,800 to 8,100
Commercial				2,000
Harvesting				
Clearcut	5,372	3,162)	4,887	15%)
Shelterwood	817	672)		) 8,900
Seed tree			1,086	80%) to
Selection	0	826	274	5% 11,500
Overstory removal	1,334	1,605	1,003	3,400 to 4,300

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[1] Flathead National Forest, unpublished data, 1972.

Table 6. Flathead National Forest Road System[1].

Year	Total miles of road	Acres lost to productivity[2]
1972	2,060	6,592
1975	2,123	7,112
Final Projection	8,000	25,600

[1] From: Draft Environmental Impact Statement, Three-Year Road Construction Program for Flathead National Forest, 1972.

[2] Calculated by assuming 3.2 acres permanently removed from productivity per mile of road constructed.

Regretfully, these data give no indication of such factors as degree of slope being cut, size of cuts, special protective measures employed, care in construction of roads, and so forth. These are the important factors in relation to maintaining water quality.

Logging practices, especially indescriminate clear-cutting have been shown to have deleterious effects on streams. A federal study (Fed. Water Pollution Control Admin., 1970) lists detrimental effects of timber management that include: increased sediments, temperature increases, and organic and mineral nutrient leaching from the soil.

Casey (1971) gathered data on Hay Creek on the North Fork drainage to determine temperature effects of clear-cutting in the area. The study revealed that daily temperature fluctuations could affect survival of coldwater fish. Casey recommended that buffer strips of natural timber and vegetation be a standard requirement on all timber sales.

It is quite probable that sizeable buffer strips would also act as a filtering and slowing mechanism on runoff, thus removing at least some of the larger sediments.

The Flathead National Forest has recognized its agency's contribution to water degradation. In the Flathead National Forest Basic Management Plan (1972), it is stated:

> "Stream habitat has been affected by logging and road building. Debris from logging activities, especially on tributaries to the National Forest (of Flathead) has created barriers to fish migration. Water temperature has been increased significantly in some areas. Silt from logging activities and road building has occurred. Road crossings have created migration barriers on many streams in the forest, and many miles of spawning habitat are not used to their fullest extent."

> "Timber management activities have been first priority on much of the Flathead for the last 20 to 30 years. Most of the timber harvesting was accomplished through clear-cutting. Clear-cutting and related road systems have had a tremendous impact on water quality and timing of run-off. On-site damage was considered tolerable in many cases but accumulative effects which caused downstream damage in several cases were not recognized."

Clear-cutting may drastically change soil moisture and base flow of streams. Krygier, Brown and Kingeman (1971), state that base flow has increased by 50-75% after entire watersheds have been cut. Spring run-off can be expected to occur at a much faster rate due to increases in solar radiation on snow. Moisture, once lost through transevaporation, becomes run-off or percolate. Rapid run-off may lessen the ability of the soil to absorb its former level of moisture in the spring. This in turn would lower available moisture for vegetation during the summer growing season. Slope and exposure are obvious factors of importance here, and large cuts on steep, south-facing slopes may take many years to re-vegetate to forest conditions.

Krygier, Brown and Kingeman (1971) have discussed in detail the effects of roading, skid trails, logging and slash burning. Minimum damage to the watershed can be obtained by well-planned logging operations. In an area with extensive planning, the maximum turbidity was recorded at 25 ppm (Jackson Turbidity Units). An adjacent watershed cut without any plan, maximum turbidities of 56,000 ppm were recorded (Reinhardt and Eschner, 1962).

Slash burning appears to be a common practice in the Flathead National Forest. Effects on watersheds from this practice are not well known (ibid).

Fredrickson (1970), reported a large increase in turbidity after burning, the increase presumably caused by the release of trapped sediments in the logging debris.

Available data on increased nutrient levels in clear-cut drainages are few. The Hubbard Brook Study (Bormann, et al, 1968), was a dramatic example of extreme nutrient enrichment of waters. Nutrient loss was eight times greater than on undisturbed areas. This loss is attributed to increased activity of soil microflora, breaking down organic matter with hydrogen ions replacing nutrients (Ca, Mg, K, Na) on soil cation exchange sites. Nitrates were lost as the result of Nitrosomonas and Nitrobacter activity on ammonia produced from decomposition of organic nitrogen.

Natural nutrient loss from the forest ecosystem is unknown for Montana. Cooper (1969) cites Livingstone's (1963) statement that nutrient concentrations, and sometimes total nutrient output, are often lower at times of high flow than at low flow. Apparently, the natural condition is for water to flow beneath the litter layer in the upper soil layers. Surface overland flow is uncommon in the natural forest system. Though traveling through the soil substrate, nutrients are not removed to any extent due to the failure of the water to remain in interstices between soil particles.

The importance of this sub-surface flow may not be fully appreciated, as Cooper states, "Thin films of water moving slowly through unsaturated soil make a major contribution to base flow of streams during dry periods (Hewlett 1961, Elrick 1963). Unsaturated flow is particularly important in the relatively steep basins with deep soil that characterize many forest catchments."

Cooper is quick to point out that generalities cannot be made unless the exact nature of the complex interactions of soils, vegetation, geology and topography are understood as factors influencing the water chemistry of forest streams. He cites Dugdale and Dugdale (1961) as discovering that the presence of alder (a plant common to the upper Flathead drainage) alongside a stream can change nitrate content by that plant's ability to fix atmospheric nitrogen, making more nitrogen available for leaching.

The forest ecosystem controls nutrient loss to streams by 1) storing nutrients in standing vegetation, 2) modifying precipitation effects on surface substrate, and 3) influencing water movements through the soil, Cooper states: "It has been demonstrated repeatedly that removal of forest cover lowers transpiration and increases runoff; however, only rather severe reduction of vegetation affects runoff significantly (Goodell, 1966)." Cooper cites Gessel and Cole (1965) as having measured nitrogen loss from a Washington forest soil before and after clearcutting. Nitrogen loss by leaching doubled, as did potassium and calcium ions. However, much more water passed through the soil after clearcutting so that actual concentrations of these ions in runoff water was not correspondingly increased.

Methods Employed in Forest Management to Prevent Water Quality Degradation

The Flathead National Forest prepares an "environmental analysis" as part of the multiple use report made before any area of the forest is put up for a timber sale. An environmental impact statement is not made except for controversial projects. In the multiple use report, some assessment of increased run-off and damage to streambeds that would occur from the potential sale is reported. Depending on the particular area evaluated, the district ranger or soil and water specialists make these evaluations. Various recommendations and/or alternatives are offered. The district ranger generally has the final decision on whether an area is to be cut, and if it is to be cut, what methods will be employed. Stipulations for protection of watersheds, unstable soil areas, etc. are written into the contract before the sale is made. Whether or not these stipulations are followed by the contractor is sometimes not clear. The

Flathead National Forest has neither the personnel nor the funds to act as a watchdog agency while a cut is in progress.

The district ranger has been trained to some extent to recognize potential soil and water disturbances caused by various methods of timber-cutting. The district ranger is usually responsible only for the final decision on where and how a road is to be constructed. His decisions, then, are critical for maintaining water quality as it may be influenced by the forested drainage. It is perhaps asking too much of a district ranger that he be hydrologist, soils scientist, limnologist and construction engineer. Limnological considerations, at least in the past, have received the least attention.

The Flathead National Forest does have specialists, including a soils scientist, fisheries biologist, and hydrologist; however, their expertise is not always employed for sales, nor their recommendations necessarily followed:

Part I of the Flathead National Forest's Basic Land Management Plan (1971) has generally outlined that certain areas of the forest are to be considered "water influence zones" with the following management criteria prescribed:

1. "Protect aquatic vegetation to this zone.
2. Viewing wildlife is a recreational opportunity of this zone. Favor protection of habitat over recreation developments and activities where conflicts exist.
3. All uses and activities will be planned to improve or maintain visual and water resources."

General forest management criteria include:

"Spawning and rearing areas for native west-slope cutthroat and Dolly Varden fish will be identified and a protection plan developed where roads and sales are planned." "Road plans will include design criteria for options which will result in . . . maintaining water quality."

"Avoid or modify harvesting in drainages involving unacceptable watershed degradation, either existing or anticipated, based on hydrologic analysis." (Emphasis ours).

An inference that can be made regarding the last statement is that the Forest Service accepts a certain unspecified degree of watershed degradation as part of their harvesting practices.

Certainly there is a new awareness for watershed protection; however, the Forest Service's ability to assess potential water quality degradation problems and insure adequate protection may be questioned.

State and corporate logging operations employ similar methods as the Federal Forest Service. Specialists are not known to assess environmental effects of logging. The State Board of Health and Environmental Sciences has regulatory power over these agencies only if stream beds are distrubed by mechanical means. Therefore, removal of stream overstory and disturbance of the soils causing thermal, sediment and nutrient increases, are legal under Montana law.

There is very little in the way of watershed protection with which this study can assist the Flathead National Forest. That agency is aware of the problems involved. On the other hand, no published studies, with the exception of Casey (1971), have measured the extent of water quality degradation caused by management activities.

Personal observation by Seastedt revealed erosion from forest roads and clearcuts, but we are simply unable--as is the Forest Service--to state the extent of the problems. Therefore, our suggestions for control measures are based on three assumptions:

1) Timber harvesting and road construction is causing damage to local watersheds by modifying a) runoff, b) temperature, c) sediments, and d) nutrients to an unspecified, locally varying degree. Downstream modification, at least increased turbidity, occurs.

2) Long term cumulative effects of logging and roads in forested lands during the last 20 years have significantly modified water quality and quantity in certain drainages of the National Forest.

3) Demand for wood and wood products will result in an intensified management program. The timber harvest, which has recently been lowered, may be increased if reforestation measures are increased.

Small sized timber cuts, less clearcutting, buffer strips around surface waters, protective measures in fragile areas, minimal damage to the forest soil mat, and well designed and constructed roads would solve most water quality problems of existing forest management activities. Unfortunately, these suggestions also raise the cost of timber. However, this increase is simply the price of maintaining water quality that has not been paid in the past. "Clean" water has been regarded as intangible and difficult to assess by cost-benefit analysis. Certainly the rapid growth in recreation and tourism is, at least in part, due to the drainage's clean water, and this form of land use may become the most important economic factor for the drainage. But to even attempt to argue water quality from an economic standpoint is invalid. This is because, as Aldo Leopold (1948) states, "It tends to ignore, and thus eventually eliminate, many elements in the land community that lack commercial value, but that are (as far as we know) essential to its healthy fuctioning. It assumes, falsely, I think, that the economic parts of the biotic clock will function without uneconomic parts." This statement, of course, applies to any land practice that lowers the natural diversity of the aquatic biota. More specifically of forest management, Wambach (1972) states, "It seems obvious that if we are going to demand a higher quality of management, more research, and a more balanced program (by which I mean more support for wildlife, water, and recreation -- not less support for timber), we will have to provide more money to get the job done."

The Flathead drainage has been the site of a running battle between the timber industry and conservationists. Economics has been the major argument by the timber industry, but many of the timber sales may be subsidized by the Federal Government. Wambach (Ibid) states,

> "Another suggestion is that we explicitly acknowledge that the timber industry in this region is subsidized. Let's abandon the pretense that it functions under the free enterprise system. It's a fact. Why not admit it? Stumpage prices paid for federal timber often do not cover the cost of administering the timber sale -- let alone the cost of growing the trees, protecting the environment, and maintaining the management agency itself. We might still justify the timber harvesting program in terms of employment, stability in the regional economy, maintainance of the health and vigor of the forest itself, etc. But if the subsidy were explicit, the public (and our political representatives) could make an open and direct choice about the kind of subsidy they wanted. If we wanted the forest cleaned up after a harvest, we could appropriate the money to get the job done. If we wanted to insist on a more expensive logging system to protect the amenity values in the forest, we could assist the logger financially (or technically). If we decided that we had a pressing need for more lumber or pulp, we could elect to pay the cost by compromising on our demands for a high quality natural environment. We do all these things anyway, but in a sub rosa fashion. Why not be overt and direct about it? We would lose nothing (as far as I can see), and we might end up by having all the facts and information out in the open. It's hard to pick the prettiest girl when your eyes are shut and your hands are tied."

Wambach is perhaps too considerate of the timber industry in this case. Private industry is making a profit by cutting timber on lands that belong to the public and is damaging watersheds in the process. Federal tax moneys support these activities.

We feel it to be the responsibility of the Flathead National Forest either to monitor streams before, during and after certain timber harvests are made or to provide funds to another agency to monitor their management activities. While this program need not apply to all areas cut, certainly large cuts and areas that have had a significant percentage of trees removed within a single drainage need to be assessed.

In each environmental impact statement or multiple use report prepared before a sale, the following information should be presented:

1) increased runoff (presently estimated)
2) increased sediments
3) thermal fluctuations
4) nutrient increases

This data should then be incorporated into an accurate assessment of damages or changes to stream biota and downstream effects.

This assessment of activities may indeed be impossible with existing personnel and funds. On the other hand, processing in the absence of unequivocal data toward proper management is irresponsible and unacceptable behavior for a federal agency.

Additional research is warranted in the Rocky Mountain forest region to determine the relationships between fire, soil nutrients and runoff. The coniferous forest envolved with fire as a naturally occurring phenomenon. Studies by Debano (1970) and Krammes and Osborn (1970) have adequately shown that forest soils respond to fire by forming a water repellant layer. Such a layer may increase surface runoff, but protect soil nutrients from leaching out of the soil into ground and surface waters. Timber harvesting, on the other hand, often destroys the soil mat and if slash is burned, it burns so hot as to vaporize the organic materials that may have formed a water repellant layer. Nutrient enrichment of surface and ground water, then, may be greater in areas cut than in areas burned.

This hypothesis should be tested, as it pertains not only to water quality but to timber productivity as well.

State and Corporate Forested Lands

State forested lands, administered under the Montana State Forester, Department of Natural Resources, are primarily located in the upper Whitefish and Swan drainages. Management of these lands may have particular impact on the Whitefish and Swan River drainages.

The State Forester's Office is required to submit an Environmental Impact statement before timber sales are made. The statement is designed after federal guidelines as published in the Federal Register: 7724-7729, 4/23/71. Within this statement is a general question concerning adverse effects on water quality. We propose that the impact statement be more specific, modeled after the proposed federal forest's statement. The state must assume the responsibility for adequate assessment of its activities. The State Forester's Office should supply funds to the State Board of Health and Environmental Sciences to assess and monitor a representative portion of its management activities to determine deleterious effects on water quality.

Corporate holdings in forested regions of the Flathead drainage are estimated at about 400,000 acres. By far the largest owner is Burlington Northern. Its management activities are crucial to water quality in the Lake Mary Ronan drainage, and are of considerable importance to the Whitefish and Swan River drainages. In recent years, the company has shown some response to public demands to curtail excessive damage to water quality from timber harvesting and grazing allotments on their lands. Legislation of controls on land management practices may still be necessary to protect water quality. The state might consider subsidizing the company for protection of streambeds with buffer strips in exchange for permission of public access to those streams.

It is perhaps only a matter of time before Burlington Northern begins extensive subdivision of its lands. Some leasing and land exchange programs currently exist. Such action will naturally lower the timber productivity of the drainage somewhat and remove public access to certain waterways, but also double and redouble water quality problems from subdivision activity. It is hoped that Burlington Northern will be responsive to the concerns of proper land planning methods.

Forestry on Indian Lands

Forested lands within the drainage on the east and west sides of the lower portion of Flathead Lake belong to the Confederated Salish and Kootenai Tribes and are administered by the Bureau of Indian Affairs. While no major waterways pass through these lands, management activities do have local impact on small streams and are of more than aesthetic concern to Flathead Lake. These lands are unique in that the State has no control over water quality and Federal control appears to be entirely regulated by the B.I.A.

Extensive damage to local water sheds have been observed by the investigators, and control measures similar to those requested for the Flathead National Forest, are warranted.

Forest Fertilization

Though no known fertilization projects have been undertaken in forested areas within the Flathead drainage, projected intensified management practices may call for such activities.

Groman (1972) surveyed the literature on the effects of forest fertilization on water quality. He found that nitrogen compounds other than nitrates were likely to be found in increased concentrations in forest streams only if fertilizers were directly applied to surface waters. As could be expected from the readily soluble properties of nitrate, this ion was the greatest and most persistent pollutant to surface waters from fertilization.

The excessive nitrate enrichment that has been predicted to be occurring within the Flathead drainage from other land use practices should be considered before another source of nitrate pollution is created. Bioassay algal programs are warranted on Flathead Lake and river waters to determine the effects of present nitrate enrichment. New land practices which add to existing nitrate levels may not be compatible with drainage management programs to curtail nutrient enrichment.

Should fertilization programs be implemented, hand application should be used in the vicinity of waterways. Aerial applications are not justified and direct application to waterways from this source is probably a violation of Montana water quality laws. (A violation would occur if direct application raised nutrient levels of a classified stream to levels specified in Brink, 1967).

The agency sponsoring the fertilization program should assume the responsibility of monitoring the effects of the fertilization project on adjacent streams by chemical analysis before and for a suitable period after fertilization.

Industrial Pollution

No industries are currently discharging wastes into surface waters. Occasional oil seepage from the Burlington Northern Station at Whitefish into the Whitefish River may still occur, but plans are underway to remove this potential source of pollution.

While surface waters are not being contaminated, ground waters are being polluted by industry. Konizeski (1968) reports the following example:

"Some well owners in the Evergreen (Kalispell suburb) area noticed a medicinal taste and brown tinge to their water. Water samples sent to the State Board of Health were found to contain phenols. An investigation by personnel of the State Board of Health revealed that waste glue from an industrial plant (plywood company) was being placed in a pit dug below the water table, and phenol compounds dissolved from the glue were assumed to have migrated southward in the ground water. Dilution of the ground water from the Flathead River helped to keep the problem from becoming more widespread."

This situation has not been corrected.

Another source of ground water contamination has resulted from the ban on burning waste wood from lumber mills. The companies, in order to dispose of this waste, have offered it as "fill". Numerous backwater channels, ditches, and low areas have recently been filled with these wood products. Samples of stagnant waters around these wastes have been reported to contain high phenol content by the State Department of Health and Environmental Sciences in Helena. The potential for these phenolic wastes to be carried in spring-run-off waters exists.

Control measures for the above two problems do not exist. Montana has no laws governing discharges into ground waters. This situation poses serious problems in areas such as the study area where ground water is believed to discharge a considerable percentage of total flow to surface waters, especially during low flow periods.

The problems with wood waste disposal, may be alleviated by the construction of a particle board plant in Columbia Falls. Wood chips, bark and other wastes of lumber industry, now being disposed by using this material as land fill, will be utilized by this plant. Liquid wastes by a plywood plant near Kalispell, however, will continue. Only groundwater quality criteria legislation appears to be the solution to the latter problem.

Watercraft

Glacier National Park reported 5,062 and 3,826 private boats entering Glacier National Park in 1970 and 1971, respectively (Glacier National Park, 1972). No data is available on boat-days within the park. Flathead National Forest reported about 7,000 power boat-visitor days on Forest Service lakes in 1971 (Flathead National Forest, unpublished data). The number of boats utilized on Flathead Lake probably corresponds to the number of homes and summer cabins surrounding the lake plus an increased factor corresponding to the number of tourists. About 1600 boats could be expected to be found either moored or in use on the lake on any day during the summer months.

The impact from this recreational use is known to contribute to turbidity and organic pollution from outboard exhaust. Toilet facilities with direct discharge through the hull, though illegal, have been known to have been used at least on Flathead Lake.

Oil and gasoline pollution contributed by outboard motors can cause tainting of fish consumed from extensively used waterways (Surber, et al, 1962). Shuster (1971) determined that microbial populations could utilize motorboat exhaust without additional nutrient supplements. Oxygen depletion, then, could be an additional detrimental effect, but certainly not a critical problem for oligotrophic lakes.

No control measures exist for preventing gas and oil exhaust wastes from motorboats from contaminating surface waters in the drainage. Some lakes, mostly in Glacier National Park, are classified to prohibit boating, however, all lakes named in this report allow motorboat use.

No previous studies or surveys have been attempted to assess boating impact on the Flathead drainage. Therefore, a survey was conducted by University of Montana Biological Station personnel as part of this study to determine the extent of this pollution source. Marinas, resorts and motels were asked to estimate the amount of gasoline sold for motorboat use, and oil consumption was then calculated to be 1/50 of this estimate. No service stations were contacted, therefore the estimates are likely to be very low. Over 620,000 liters of gasoline and 12,400 liters of oil were used to fuel boats operated in Flathead Lake during 1971. Motorboat operation on Lake Mary Ronan utilized over 17,000 liters of gas and 340 liters of oil during 1971.

Shuster (1971) determined that a two-cycle outboard engine discharged between 3% to over 30% of fuel consumed to surrounding waters. The study also estimated one engine-day to discharge 9.6 liters of fuel. This discharged fuel, estimated to be 85% degradable carbon, was considered to be equivalent to the wastes of 400 people. Assuming that about 15% of all fuel in motorboats is the average discharge to surrounding waters, then over 95,000 liters of fuel is discharged annually into Flathead Lake. Lake Mary Ronan receives about 300 liters of fuel annually. These discharges are the pollutional equivalent of the wastes of almost 4,000,000 and 12,000 persons for Flathead Lake and Lake Mary Ronan, respectively! No evaluation or correction factor has been made for inboard motorboat use.

The validity of these estimates may be questioned for a number of reasons, however, the figures are certainly an indication that motorboat use may have significant impact on productivity of the Flathead basin lakes. Most of the pollution from motorboat discharges occurs during the summer months. Assuming motorboat use to be increasing at the same rate as tourism, this pollution source will increase at 8% or more per year, and double in 8 years or less.

Additional research is warranted to determine 1) a more accurate estimate of engine fuel discharge into Flathead basin lakes, 2) the effects of fuel discharges on water quality with reference to factors that stimulate microbial growth, and 3) effects of fuel discharge on planktonic and periphytic algae. This information is imperative in establishing regulatory criteria.

Shuster (Ibid.) reports that a significant outboard motor pollution abatement device has been designed by the Goggi Corporation. This "Goggi" device is capable of recycling fuel that otherwise would be discharged to surrounding waters. Since fuel wastage is often a considerable percentage of fuel consumed, the economics of such a device appear very beneficial to mototboat owners. Inboard engines, similar to automobile engines, can install similar pollution abatement devices.

Legislation requiring installation of these pollution abatement devices appears warranted from data collected for this study and a review of the literature available on outboard motor pollution. While State legislation is preferred, local county governments are encouraged to take action to protect the Flathead basin lakes.

Reservoir Operation

There are 3 reservoirs in the upper Flathead drainage with capacities over 20,000 acre-feet (Montana Water Resources Board, 1968). Ashley Dam has a capacity of 20,000 acre-feet. Its purpose is solely for irrigation, and it is constructed with earthfill.

Bigfork and Hungry Horse dams serve to produce hydroelectric power; Hungry Horse dam also serves for flood control. Its use for recreation and irrigation, however, has not been utilized to any extent.

Hungry Horse Dam is 5.2 miles upstream from the confluence of the South Fork with the Flathead River. The dam generates 285,000 kilowatts. Usable storage is 2,982,000 out of a total of 3,468,000 acre-feet (Bureau of Reclamation, 1959).

The Bigfork Dam is a flow-of-the-river diversion dam on the Swan River at Bigfork. The dam is capable of generating 4,150 kilowatts (Bureau of Reclamation, 1959).

Discharge rates and resulting streamflow, temperature, nutrients and BODs modifications have been recorded as changes caused by the impoundment (Kerr Water Research Center, 1971).

Hungry Horse Dam has prevented movements of Kokanee Salmon, Dolly Varden and Cutthroat Trout of Flathead Lake from gaining access to spawning grounds in the South Fork drainage. Kokanee Salmon have been reported to move 60 miles above Flathead Lake. Dolly Varden and Cutthroat Trout have been recorded to move 99 and 102 miles, respectively (Hanzel, 1964, 1965). These fish, then, did utilize much of the South Fork drainage before the dam was constructed. According to Schumacher (Pers. Comm), 50% of all available spawning sites of trout and salmon have been lost.

Violent fluctuations in streamflow have been reported below the dam. Such fluctuations could be expected to be deleterious to the benthos, restricting these organisms to the unaffected portion of the streambed.

This in turn would limit the amount of food available for fish which could survive stream fluctuation.

Hungry Horse Dam modifies downstream water temperatures by releasing water from the Reservoir's hypolimnion at penstocks located at 285 and at 325 feet below maximum pool elevation (Hanzel, 1965). Water temperatures are stabilized around 39 degrees Farenheit during the winter months. Fluctuations in streamflow between July and October caused by power demand, result in temperature variations up to 24 degrees in a 24 hour period (Domrose, 1971). Abrupt changes of temperature may be harmful or deadly to fish even within normal tolerance ranges (Huet, 1962).

The reservoir acts as a settling pond for suspended solids. Turbidity is usually not appreciable in waters below the dam. Hanzel's data (1965; 1967), reveal that dissolved oxygen, alkalinity, and standard conductance on the South Fork are generally lower and subject to less fluctuation than data obtained from the Flathead River at Columbia Falls. Reservoir operation cools summer water temperatures and warms winter water temperatures of the entire Flathead River from Columbia Falls to the lake. Sonstelie, (personal communication), notes that increased flow from the reservoir during low flow periods of August-September allows for swifter flow of the Flathead River below Columbia Falls and may act as a flushing agent for organic growths that might otherwise take place in this part of the river.

There are no known ways to correct the damage caused by this reservoir without impairing the functions of power and flood control of the dam.

Schumacher (Ibid) reports that the Bigfork Dam creates a partial barrier to spawning grounds of Flathead Lake fishes and causes added warming of Swan River waters. As the power generated from this facility is very minimal, Schumacher suggests removal of the dam to re-establish full use of available spawning sites in the Swan drainage.

For protection of the rare and endangered west-slope cutthroat trout and other biota, we strongly recommend no further damsites be developed on the upper Flathead River system.

Kerr Dam, below Flathead Lake, controls the lake level and has modified the Flathead River up to a point in the Kalispell valley known as Foy's Bend. While the lake has not risen above previously known flood stage levels, the lake remains at what were previously considered flood stages for about a 3 to 4 month period. Some increased bank erosion and increased organic inputs from decaying vegetation are acknowledged as having been increased by the continuance of raised levels caused by the dam.

At present, the dam regulates about ten feet of water. Plans have been suggested to allow the dam to regulate the lake by 20 feet. Destruction of a considerable area of littoral habitat would occur should this plan be accepted, and we are emphatically contraposed to such a plan.

Lake stabilization projects are planned for Whitefish Lake and being considered for Swan Lake. Such modification could cause problems similar to Flathead Lake unless proper planning and design measures are considered.

Whitefish Lake

Available data on Whitefish Lake are limited to Montana Fish and Game fish-census sampling and contour mapping (Schumacher, per. comm.). A few coliform bacteria samples indicate contamination from septic tank seepage (Espeland, Flathead County Sanitarian, unpublished data). No chemical studies have been conducted.

Whitefish Lake has been described as "a miniature Flathead Lake" (Sonstelie, per. comm., 1972). Though considerably smaller (surface acreage, 3350 acres) (Figure 7), it is similar to Flathead Lake in origin and in certain physical characteristics. The drainage area is estimated at about 125 sq. miles (Figure 8). No data are available for inflow from its major tributaries, Whitefish (Swift) Creek and Lazy Creek, Whitefish River and a stream gaging station 8 miles north of Kalispell that reported an average flow of 191 cfs for a 21 year period. A large part of this flow can be attributed to the discharge from Whitefish Lake. A stream gaging station is scheduled for Whitefish Lake's largest tributary, Whitefish (Swift) Creek, that should be operational in the very near future.

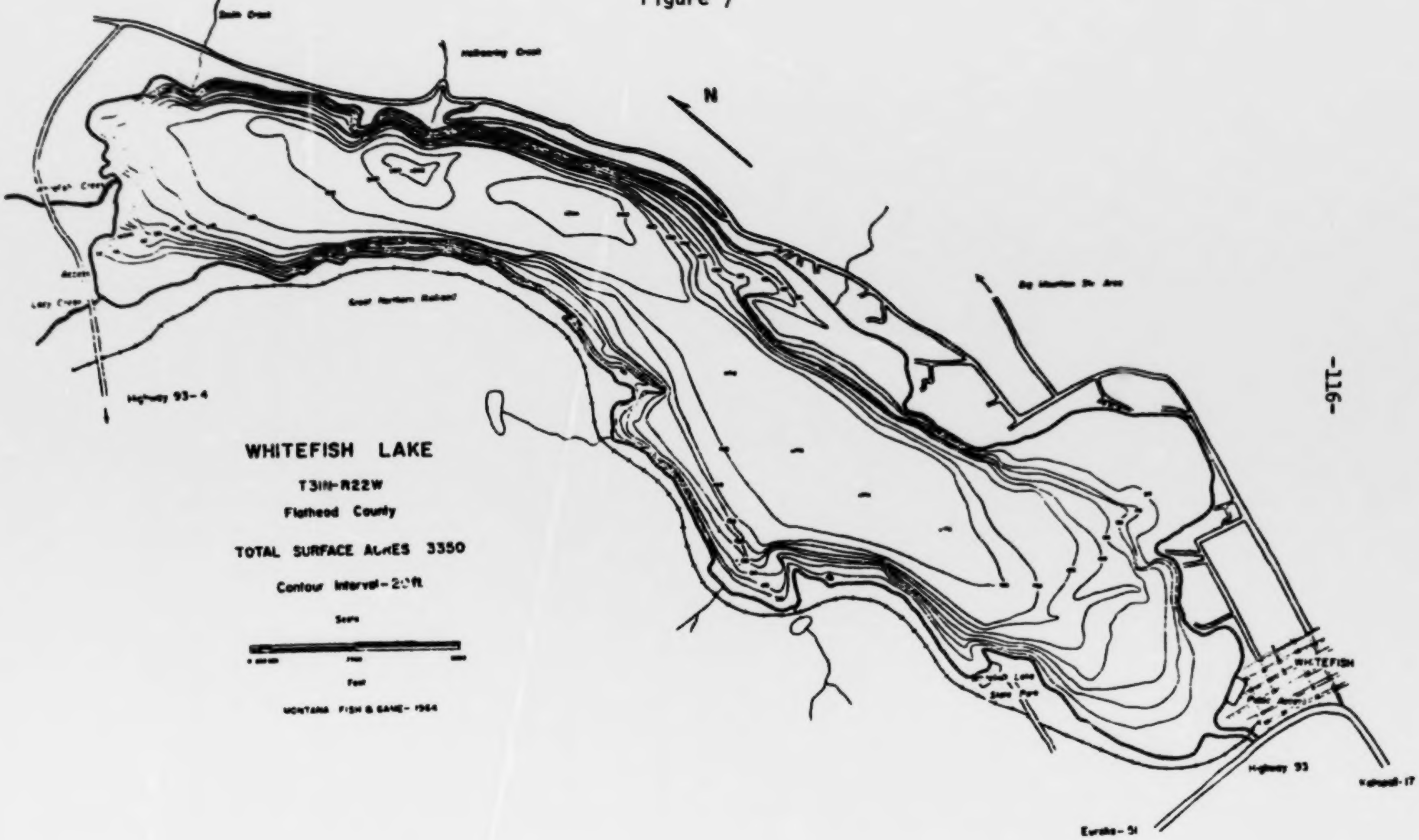
Water quality problems are believed similar to those of Flathead Lake; however, contributions from municipal sewage and irrigation return flows do not occur.

As Figure 8 illustrates, the drainage is predominantly owned by the State of Montana and Burlington Northern, hence proper forest management practices are essential to prevent water quality deterioration.

Subdivision activity is rapidly dividing the prime recreational lands within the drainage, especially around Whitefish Lake, into smaller and smaller parcels for summer home use. A major condominiium development is being constructed on land just east of Whitefish Lake.

The extent of livestock activity in the drainage is not known.

Figure 7


N
Hellroaring Creek
Access
Lazy Creek
Great Northern Railroad
Highway 93-4
Big Mountain Ski Area
State Park
WHITEFISH
Public Access
Highway 93
Kalispell-17
Eureka-51
WHITEFISH LAKE
T31N-R22W
Flathead County
TOTAL SURFACE ACRES 3350
Contour Interval-20 ft.
Scale
Feet
MONTANA FISH & GAME-1964

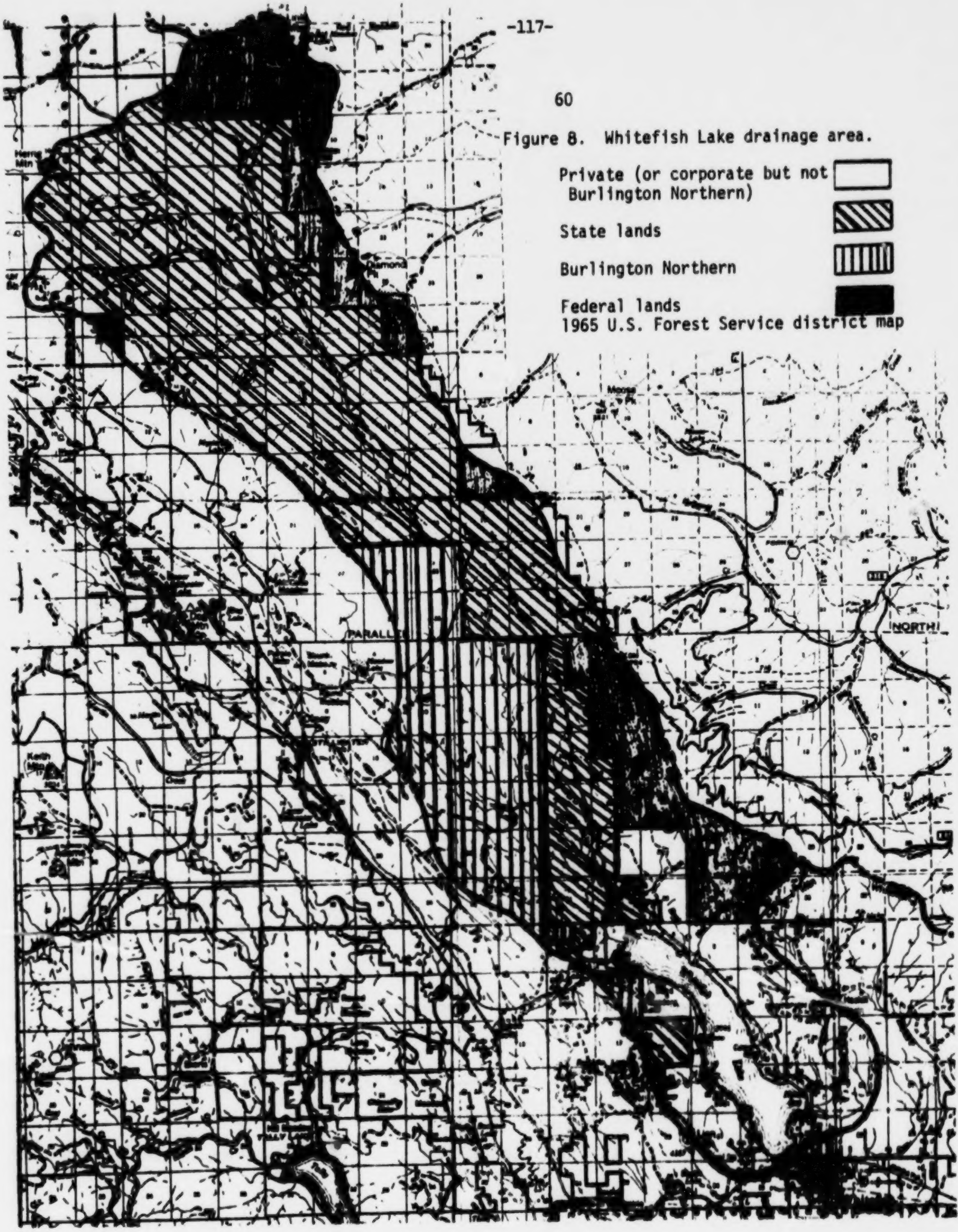


Figure 8. Whitefish Lake drainage area.

Private (or corporate but not Burlington Northern)	☐
State lands	▨
Burlington Northern	▥
Federal lands	■

1965 U.S. Forest Service district map

No water quality data exists for this lake. The rapid rate of growth of subdivision development and tourism necessitate that a comprehensive study of the chemical, physical, and biological characteristics of the lake be undertaken to provide baseline water quality information. While a year-long study is desirable, a summer study would suffice to gather baseline data on the following parameters:

Physical:	Vertical temperature profiles
	Turbidity - light intensity and penetration
Chemical:	Those outlined by the State in preliminary report II, plus ammonia and organic nitrogen, total organic carbon, and total phosphorus
	Vertical oxygen profiles
Biological:	Quantitative and qualitative plankton analyses
	Carbon 14 a productivity measurement
	Coliform bacteria analysis
	Gill-net surveys

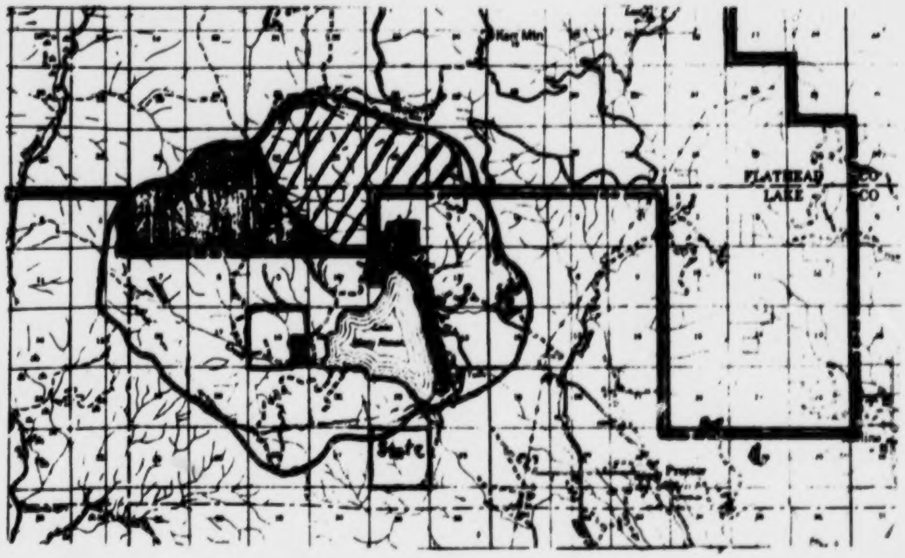
Since the State is monitoring the two major tributaries above the lake, water chemistry information from the lake would reveal 1) the degree to which land practices above the lake are affecting water quality, as opposed to 2) the effects of developments surrounding the lake. Specific control measures can then be aimed at those activities believed to be the most serious sources of water quality degradation.

Lake Mary Ronan

Lake Mary Ronan is a particularly productive lake well on its way to eutrophy.

Personal observation has revealed high quantities of vegetation, zooplankton, and large numbers of warm-water fishes. The lake is small, (about 3000 acres), shallow, (47 foot maximum depth), with small volumes

Figure 9. Drainage area, Lake Mary Ronan.



U.S. Forest Service Boundary ━━ ▬▬

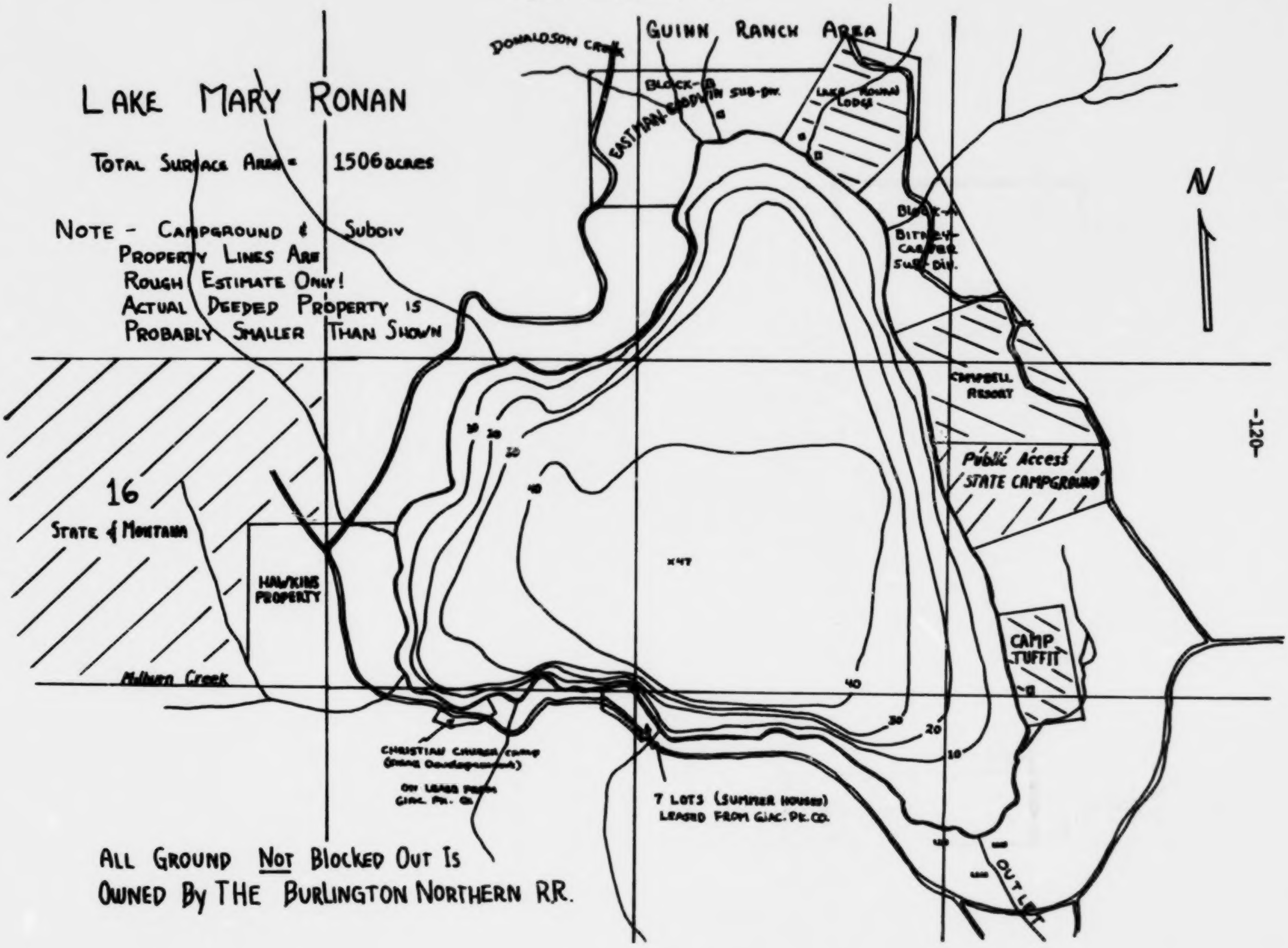
Logging Project ▨

Sec. 16 as delineated belongs to State of Montana (clearcut 1969).

Areas not shadowed are property of Burlington Northern Railroad.

(From Aikin, 1970)

Figure 10. (Aikin, 1970)


LAKE MARY RONAN
TOTAL SURFACE AREA = 1506 ACRES
NOTE - CAMPGROUND & SUBDIV PROPERTY LINES ARE ROUGH ESTIMATE ONLY! ACTUAL DEEDED PROPERTY IS PROBABLY SMALLER THAN SHOWN
DONALDSON CREEK
GUINN RANCH AREA
BLOCK-B
EASTMAN-GOODWIN SUB-DIV.
LAKE RONAN LODGE
BLOCK-A
BITNEY-CARVER SUB-DIV.
N
CAMPBELL RESORT
Public Access
STATE CAMPGROUND
CAMP TUFFIT
16
STATE of MONTANA
HAWKINS PROPERTY
Milburn Creek
x47
10
20
30
40
CHRISTIAN CHURCH CAMP (UNDER DEVELOPMENT)
ON LEASE FROM GIAC. PK. CO.
7 LOTS (SUMMER HOUSES) LEASED FROM GIAC. PK. CO.
OUTLET
ALL GROUND NOT BLOCKED OUT IS OWNED BY THE BURLINGTON NORTHERN RR.

of water entering from the surrounding drainage. Cattle are allowed to graze around much of the drainage, and logging on private lands within the drainage has occurred. A logging operation is beginning this summer on National Forest lands, with road building already underway. Coliform bacteria counts along the shoreline have not shown any gross pollution from surrounding resorts (Robertson, unpublished data).

The Montana Fish and Game Department conducted a study to determine dissolved oxygen profiles during the summers of 1969, 1970 and 1971 (Domrose, 1970, 1971, 1972). Kokanee salmon habitat was found to be restricted to the thermocline, or one vertical foot of water, because of oxygen and temperature tolerance limitations.

A study was conducted during the week of July 17, 1972 by University of Montana Biological Station students and staff under the direction of Dr. Arden Gaufin. Physical, chemical and biological characteristics of the lake were determined. Chemical and physical data agreed with earlier studies conducted by the Montana Fish and Game Department (Domrose, 1970, 1971, 1972). Bacteriological and plankton data obtained enhanced information on the extent of eutrophication of the lake.

Coliform bacteria and fecal streptococcus tests were conducted (Table 7).

Table 7. Bacterial contamination of Lake Mary Ronan

Area Sampled		Total Coliform Colony Counts[1] July 20	Total Coliform Colony Counts[1] August 6	Fecal Strep Colony Count[2] July 20
1, 2	Inlet at Bible Camp	740	550	84
3	Hilburn Creek South Fork		990	
4	Hilburn Creek North Fork		640	
5, 6	Outlet of Lake Mary Ronan	1040	930	76
7	Tuffit Camp	130		32
8, 9	Public Swimming Area at Recreation Area	158	190	10
10, 11	Donalson Creek at Bridge Near Lake	1900+	4610+	1050+
12	Donalson Creek at Entrance to the Lake	1500+		192
13	Lake Mary Ronan Lodge	20		6
14, 15	Swimming Area at Bible Camp	370	120	15
16	Center of Lake Mary Ronan (Surface Sample)	2		2

[1] Standard Methods: Total coliform membrane filter procedure.

[2] Standard Methods: Fecal streptococcus membrane filter technique.

Quantitative information on plankton populations was not clear because of differences in sampling methods used during the study. However, the most numerous organisms, listed in the order of abundance, are as follows:

Aphanizomenon spp.

Anabaena spp.

Ceratium spp.

Daphnia spp.

Fragilaria spp.

Pandorina spp.

Volvox spp.

Bacterial contamination within the lake itself is not as high as at the inlets, indicating that possible septic tank failure from resorts and private homes is not the cause. Numerous cattle observed throughout the drainage (and indeed in the lake itself) are surely the major factor causing enrichment. Logging on state and Burlington Northern lands appears to have caused some increased nutrient inputs. Likewise, a logging operation currently underway on federal lands can be predicted to cause some deleterious effects on the lake (Figure 9).

How Lake Mary Ronan qualified for A-open-D1 classification (Brink, 1967) may be questioned, but permitting continued bacterial and nutrient contamination is a mockery of Montana's Water Quality Standards.

Because the lake constitutes a popular cold water fishery, it would be economically advantageous to enact strict protective measures, including:

- total removal of cattle from the watershed, or drastic herd reduction with fencing to prevent direct access to the lakes and feeder streams.

-strict protective restrictions on timber harvesting, delineation of unstable slopes and total protection of stream overstory with required buffer zones protecting adjacent streamside vegetation.

Septic tank systems, while not shown to cause bacterial contamination, are a source of nitrate enrichment. The three resorts and campgrounds along the lakeshore (Figure 10) should consider alternative methods of sewage disposal.

We estimate outboard motorboats contribute an organic carbon source equivalent to the wastes of 12,000 persons. Pollution control devices should be installed on boats utilizing this lake.

Burlington Northern Company owns much of the drainage; the fate of the lake is in their hands. The company might find it economically feasible to utilize their lands for limited resort-subdivision development and provide artificial aeration to the lake.

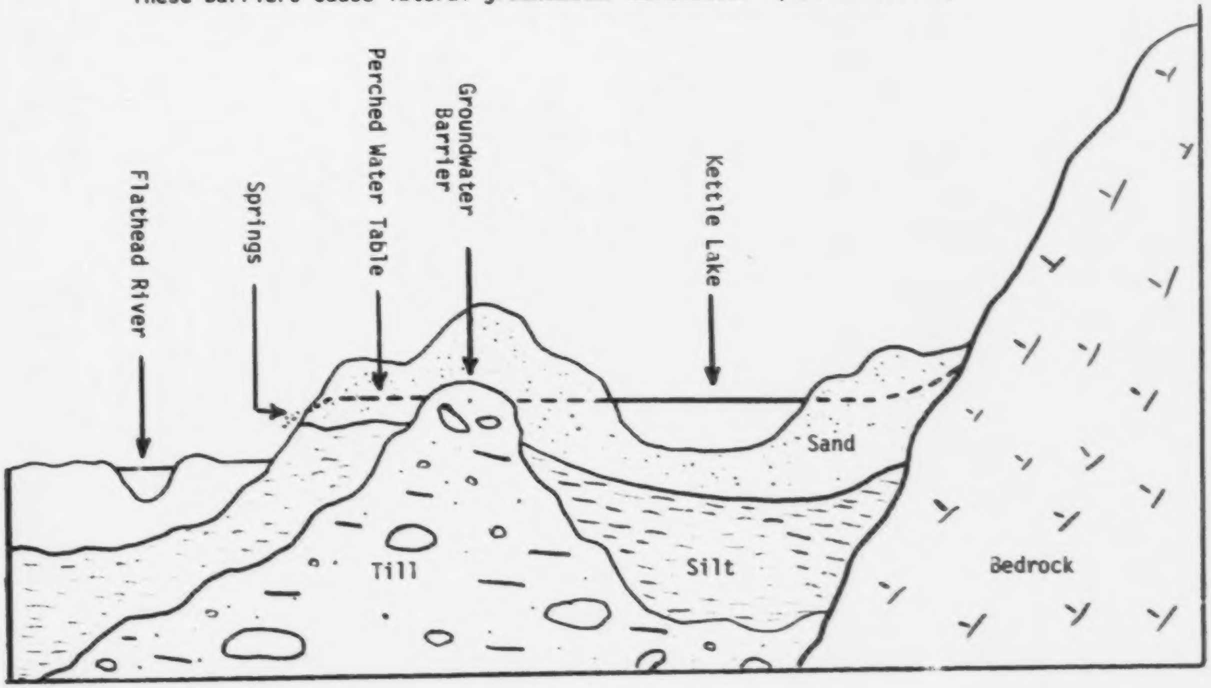
Whatever management plan is implemented, it should be made clear that continuation of the existing situation will cause severe algal blooms with an eventual fish kill that will mark the end of the cold-water fisheries for that lake.

Kettle Lakes Region

The Kettle Lakes region is an area of more than 30 lakes northeast of Bigfork. These lakes are small, varying from unnamed ponds of less than an acre in surface area, to Echo Lake, which is reported to have a surface area of 700 acres (Konizeski, et al., 1968). These lakes, because of their unique construction and hydrology, appear to be very fragile and may not withstand increased human use. At present, and sadly, however, the entire area is planned for subdivision development.

Human activities are believed already to have seriously modified the hydrology and water quality of Echo Lake. Not only is the lake reported to be entering nuisance phases of eutrophication, in addition the lake level itself has been rising and flooding summer homes and their sanitary facilities. A recent report by the Bureau of Reclamation (1972) concluded that diversion of a small stream into the lake has caused the problem. However, Konizeski (pers. comm.) believes that increased precipitation and the clearcutting of a significant percentage of the drainage has caused increased groundwater flows to the lake. The Bureau of Reclamation apparently did not consider the groundwater hydrology of the area. The fact that the lake reaches its peak height in late July, rather than early June after peak runoff supports a groundwater increase rather than surface flow increase. The rather expensive control measures to divert surface runoff from the lake as proposed by the Bureau may have little effect on lake levels.

Figure 11. Simplified drawing of perched aquifer of the Kettle lakes region showing groundwater barrier (Konizeski, et al., 1968).
These barriers cause lateral groundwater movements. (Not to scale.)


Flathead River
Springs
Perched Water Table
Groundwater Barrier
Kettle Lake
Sand
Silt
Till
Bedrock

Konizeski, et al. (1968), has shown that the Kettle Lakes are little more than depressions below a perched aquifer (Figure 11). The lakes fill and drain with groundwater flow. Hence, the lakes will rapidly become eutrophic if the groundwater is enriched by septic tank use. Septic tanks and drainfields in use around the lakes are very close to, if not periodically innundated by, groundwater.

Echo Lake and Lake Blaine receive extensive motorboat use which may add considerable amounts of hydrocarbons. While specific data for these lakes are lacking, motorboats are believed to contribute significant quantities of hydrocarbons to Flathead Lake and Lake Mary Ronan. Control measures similar to those suggested for those lakes may be warranted for Echo Lake and Lake Blaine.

Clearcutting that has occurred within the Kettle Lakes drainage may have significantly increased groundwater flows. A number of these cuts are above or on what is believed to be the major recharge area for groundwater. Some increase in nutrient levels to groundwater is believed to have occurred from this activity. As suggested elsewhere in this report, activities over major recharge areas should be further researched for impact to groundwater quality and quantity.

The potential subdivision development of this area should not be permitted unless some form of municipal or individual closed sewage systems are provided.

Other Lakes of the Flathead Drainage

Other lakes of the Flathead drainage system of fairly large size, of recreational importance and in danger of eutrophication, include Swan, Ashley and Tally Lakes. We have excluded the lakes within Glacier National Park as the Park Service is charged with the responsibility of maintaining those lakes in their natural state. National Park Service directives necessitate that the Park 1) remove any source of sewage discharge as is being done in the Lake McDonald area and 2) prevent groundwater enrichment, and subsequent surface water enrichment, from septic tank systems. The Park Service may have to resort to other forms of sewage disposal than are currently being used for its campground facilities to prevent nitrate enrichment.

Tally Lake, while relatively small (surface area, 1,326 acres) is a beautiful lake in the Flathead National Forest northwest of Kalispell. It is unique in that it is the deepest lake in the drainage; it is over 450 feet in depth, and its maximum depth is not known. (Mont. Fish and Game Dept. contour map, 1967). Seastedt observed a large algal bloom in mid-July on the lake that was identified by Dr. G. W. Prescott, U. of M. Biological Station, as Anabaena flos-aquae. This blue-green alga, in addition to other nuisance characteristics, is responsible for production of substances toxic to livestock. Seastedt observed many large clearcuts and many cattle in the drainage of Tally Lake. These factors were believed to contribute the nutrients responsible for the algal bloom.

Ashley Lake, a fairly large lake (surface area, 3,244 acres) west of Kalispell, superficially appears to be a relatively clean, oligotrophic lake. (However, this was the case with Tally Lake until the algal bloom was observed.) The upper few feet of this lake are regulated for irrigation purposes. The drainage area of Ashley Lake consists of corporate, private, State and Federal ownership. Burlington Northern Corporation is believed to own a considerable portion of the area. Private holdings and summer homes appeared numerous around the lake.

Swan Lake is another fairly large lake (surface area, 2,680 acres) located east of Flathead Lake. The drainage area of this lake is quite large, over 500 square miles. Quite a volume of water passes through the lake yearly, as the Swan River averages about 1,200 cfs as recorded at Bigfork. The drainage is in multiple ownership, with the Flathead National Forest, Burlington Northern, and the State forest owning much of the land. Anticipated water pollution problems are similar to those stated for Whitefish Lake.

But for Montana Fish and Game fish surveys and occasional grab samples for temperature, dissolved oxygen, standard conductivity, pH and alkalinity, no information is available on the water quality of these lakes. Baseline water quality data are essential, and must be gathered as soon as possible. Such data are the *sine qua non* of future management. The rate of subdivision, recreation, timber management, and other activities appear to be intensifying in all of these drainages.

Pesticides and Herbicides

Use of chlorinated hydrocarbons has declined in recent years in the Flathead drainage. Other short-term toxins are used or permitted for use by several agencies to control plant and insect pests.

The Flathead National Forest has ceased to spray the forests to control insect infestations; however, the Forest Service can, under certain conditions, spray for insect control.

The Flathead mosquito control district has used organic phosphates and pyrethins to control insect larvae during this past year. Baytex (O,O-Dimethyl O-(4-Methyl + h1O)-m-folyl) phosphorothioate), Lethane - 384 (B-Butoxy-B^1-thiocyano diethyl ether), Malathion (O,O-Dimethyl phosphoro dithidate of diethylmercaptosuccinate) and Pyrethrins were utilized to control mosquito larvae and adults.

Weed control personnel use 2-4-D (2-4-Dichlorophenoxyacetic acid) predominantly to control weed growth on over 10,000 acres in Flathead County.

Chemical treatment of cherry orchards on the east shore of Flathead Lake includes application of the following: Diazinone (Geigi Chemical Co.), sulfur, Benlate (Dupont), Parathion (Stopher and Niagra Chemical), Guthion (Chemical Agricultural Corp.), Malathion (American Cyanamide), and a paraffin-based spray-oil. Amounts of chemicals applied are not known; however, Diazinone is most widely used. Acreage for orchards is increasing, especially on the south shore and Finley Point areas of Flathead Lake.

Individual use of herbicides and pesticides has not been assessed but is believed limited to organic phosphates and 2-4-D.

The U. S. Geological Survey (1970) reported no measured clorinated hydrocarbons (.00 micrograms per liter) for the three forks of the

Flathead River. Tourangeau (1969), however, reported eggs of ospreys on Flathead Lake to contain up to 135 parts per million (ppm) DDT.

Gaufin (pers. comm. 1972) believes that if chlorinated hydrocarbons are to be found within the aquatic ecosystem, the area of concentration and accumulation would be in bottom sediments and not in the water itself. According to Sonstellie (pers. comm. 1972), certain drainages that were sprayed long ago have not shown complete recovery as evidenced by the present lack of certain Plecoptera (stone flies) which were previously to be found in the streams.

There is ample opinion that the use of chlorinated hydrocarbons should be totally banned from use. This is certainly our recommendation for the Flathead drainage. Organic phosphates used by mosquito control personnel and crop growers, in general, are reported to have only short-term toxic effects. Baytex (reg. Chemagrow Corp.) is reported to hydrolize in a few weeks (Chemgro Corp. 1967). However, this pesticide is reported toxic to certain aquatic organisms of concentrations of 5 parts per million (ppm) or less (Kemp, Abrams and Overbeck, 1971). Malathion has reported half life on the soil of 4 days (American Cyanamid Co. 1967). This pesticide has been reported toxic to Rainbow trout fry at concentrations of 1.0 parts per million (ppm) (Kemp, Abrams, and Overbeck, 1971). Diazinon (O,O-diethyl O-(2 isopropyl-4 methyl-6 pyrimidinyl) phosphorothioate), the pesticide most commonly used in Flathead cherry orchards, is reported to have no residual effects (Geigy Chem. Corp., 1967). This chemical is reported toxic to Rainbow trout at concentrations of less than 0.2 parts per million (ppm) and toxic to certain zooplankton at concentrations of less than 1 part per billion (ppb) (Kemp, Abrams and Overbeck, 1971).

While long term effects of these chemicals are not known, it is quite apparent that these chemicals must be applied properly and carefully to prevent poisoning of aquatic organisms. Aerial spraying, then, should be discontinued in certain areas of the drainage.

Chemical controls, in general and in the long run, are likely to fail because of the reproductive and adaptive ability of the target insects. Responsible agencies involved in insect control should realize this fact and use chemicals only after all available forms of biological control have failed. Of course extensive research should be undertaken toward the goal of manageable biological control.

Herbicide use should be limited to chemicals rapidly destroyed by soil bacteria or other means of breakdown. Again it should be recognized that these chemicals are toxic to aquatic organisms at very low concentrations and should be used with care around waterways.

The investigators are concerned that the weed control personnel might be perpetuating their roles by creating disturbed sites by continually spraying and cutting the "weeds". Naturally, this creates a setting for primary succession where the pioneer plant is inevitably the same or another "weed". Overgrazing, another cause for weed growth, should not be encouraged by county-funded programs to protect mismanagement practices. The weed control program should be reviewed. Perhaps it will not be possible to justify the program in future drainage management practices.

Biological indicators are useful in assessing potential toxicity to aquatic life caused by indiscriminate use of pesticides and herbicides. Certain members of the Plecoptera (stone flies) and other insects have been recognized as sensitive organisms. Organisms of higher trophic levels (such as trout or the osprey) have been recognized to accumulate chlorinated hydrocarbons, and periodic analysis is warranted as long as, and perhaps long after, these chemicals have been used in the drainage.

Bacteriological Monitoring

We suggest that a comprehensive bacteriological monitoring program be established for the Flathead basin lakes. The membrane filter technique for total coliform bacteria is a simple yet sensitive method for determining fecal contamination. This test is valid for detection of possible violations of Montana's Water Quality Criteria (Brink, 1967).

All agencies involved in activities, including management of campground facilities or issuance of grazing permits that could cause bacteriological contamination should be made responsible for seeing that activities are not violating Montana law. Agencies should either monitor these sources themselves or fund either the State or the County to do so. The Forest Service should provide for the monitoring of streams and lakes adjacent to their campgrounds and in drainages where cattle allotments have been sold. The State should do likewise. Glacier National Park officials should monitor lakes and streams adjacent to their campground facilities.

Private campgrounds, motels, and summer homes should be monitored by County sanitation personnel. An increased number of personnel than exist at present may be required for this work. However, monitoring could be limited to the summer months when the use of these facilities is high. The sanitarian's office should also monitor potential bacterial contamination from cattle grazed on private lands. Spring runoff and low-flow periods may be the most appropriate times to monitor these areas.

Environmental research needs for assessing water quality problems in the Flathead drainage.

Mr. David Nunnallee, Environmental Sanitation Engineer for the State Department of Health and Environmental Sciences has prepared a tentative list of research needs required to understand more fully the water pollution problems of the Flathead drainage. A complete description and study outline prepared by Nunnallee has been included as an appendix to this report. We concur with these research needs and would expand certain aspects of the studies.

As mentioned in numerous sections of this report, groundwater movements and chemistry need to be more fully understood. The effects of subdivision development, recreation, agriculture, livestock and forest management practices all need to be assessed for impact on groundwater quality, quantity and movement patterns. Major recharge areas for groundwater need to be identified.

Nunnallee has outlined the need to assess nutrient inputs from the spectrum of land use activities. While this report has attempted to provide such an assessment, the evaluations suffer from a lack of data. Indeed, more estimates have been obtained by utilizing pollution input per unit of land practice, as found by other researchers, recalculated with Flathead drainage statistics on that land practice. The degree of error of such calculations is dependent upon unaccounted variables and the accuracy of available statistics. Our assessment of pollution inputs, then, are acknowledged to be extremely rough estimates, and further researches into deleterious effects of land use activities on water quality are warranted. We do, however, feel confident enough in these estimates to justify implementation of suggested control measures.

Water chemistry data in undisturbed areas would be of interest to assess further the extent of water pollution in the drainage. Such data could be obtained from Glacier National Park, the upper Middle Fork, the upper South Fork, and other areas.

Should the State Board of Health and Environmental Sciences be able to expand their chemical analysis program, certain additional tests are suggested. Eutrophication indices as discussed by Hooper (1969) not being sampled by the State include sodium, potassium and calcium. Pollution indices could be enhanced with the sampling for ammonia and organic nitrogen. Productivity measurements could be obtained by utilizing Carbon 14 or Chlorophyll-a measurements.

Bioassay experiments, utilizing both in situ algal techniques and laboratory algal assay techniques should be conducted to determine 1) which nutrients are limiting growth factors for certain representative species of phytoplankton of Flathead Lake, and 2) the critical levels of nutrients needed to cause eutrophication of Flathead Lake. Miller and Maloney (1971) have found that algal assays appear to be more sensitive than standard chemical analyses in determining and predicting the effects of enrichment on natural waters. While it is believed that no one factor can stimulate excessive productivity, waters have been recognized to be phosphorus and/or nitrogen sensitive. McGauhey, Dugan and Porcella (1971) found Lake Tahoe waters to be nitrogen sensitive. Sinning (pers. comm. 1972) in his preliminary analysis, believes Lake McDonald in Glacier National Park to be phosphorus sensitive. If the growth-stimulating nutrient(s) can be determined for Flathead Lake, control measures can be directed toward the nutrient(s), and the desired control measures may or may not need to be as stringent as has been proposed by this report. Tabellaria quadrisepta, a diatom abundant in Flathead Lake and which was shown by Morgan (1970) to be a cold water plankter requiring high nutrient concentrations, might serve as one species for these experiments.

To compliment bioassay studies, knowledge of certain physical and chemical parameters are essential in determining the relationships between nutrients and productivity. The hydrologic budget should be determined for Flathead Lake. The outline of Simons and Rorabaugh (1971), used to determine the hydrology of Hungry Horse Reservoir, could simplify this research. Seasonal current patterns and benthos water interactions, at present only superficially understood, need further study. Finally, the total nutrient budget of the lake should be determined by utilizing existing information, the preceding suggested research, and some additional analyses.

Summary of Existing Programs to Monitor or Control Water Pollution

The existing monitoring system for measuring water quality will gather baseline water quality data for those streams being monitored. The stations and number of samples represent the maximum load the State can handle with existing personnel. All stations will be monitoring some pollution sources. Most stations will be receiving pollution from a number of sources making identification and extent of individual pollution sources impossible. Pristine (historical) water quality is lacking for most stations, making it impossible to assess the extent of cultural pollution.

An additional station on the Flathead near Bigfork appears necessary to determine total pollution load of the upper Flathead and to assess affects on Flathead Lake. Additional sampling (more than once a month) is believed to be necessary to assess what are believed to be peak pollution periods during peak flow periods and in late August - early September.

Methods employed for municipal sewage treatment are or soon will be adequate to prevent oxygen depletion below outfalls. Exceptions may include Ashley Creek, especially during low flow periods, and the Whitefish River during extremely cold periods. Though nutrient removal is low, total input to the upper Flathead Drainage is relatively small.

Individual sewage systems, including septic tanks and other methods, are comparatively unregulated. Monitoring is time consuming and currently not possible due to lack of qualified county personnel. Growth in the use of these systems is rapid while knowledge of the overall effects on water quality are not well known, but may represent a serious problem.

Industrial discharge to surface waters is not believed to exist in this region. Wood wastes and chemicals are polluting ground waters, but no regulations exist to control these practices.

Irrigation return flows are small at present due to small amounts of total irrigation water utilized, and insufficient amounts applied per acre. No controls are employed to prevent high solute content in return flows to groundwaters. Return flows to surface waters may not be significant and have not been measured in the upper Flathead drainage.

No controls are employed to prevent animal wastes from entering surface waters. Feedlot pollution may not be problematical at the present time, but it has been in the past. Livestock are seriously polluting Lake Mary Ronan. The addition of nutrients from animal wastes is believed to enrich significantly both surface and ground waters.

Insufficient research of Rocky Mountain forest ecosystems prevents an accurate assessment of nutrient input to surface and groundwaters from forest management practices. In the past, timber cutting and road construction proceeded with only cursory attention to water quality degradation. At present, neither sedimentation nor thermal or chemical changes to water quality are properly evaluated. Approval of road design, size and type of cut on Federal lands is usually the decision of the district ranger. Specialists in the fields of fisheries biology, hydrology, and soils science are not always available to evaluate environmental effects of management activities. Their recommendations have not always been followed. Specifications to protect streams and fragile areas are assumed to be followed by individual contractors. Monitoring by Forest Service personnel is not always possible. The Flathead National Forest has neither the funds nor the personnel to assess adequately environmental degradation to water quality (e.g. sedimentation, thermal, and nutrient changes) caused by their management activities. Educational programs by the regional and forest offices are improving this situation by training existing personnel.

The State Board of Health and Environmental Sciences is unable to control water quality degradation from State and private forestry practices when actual mechanical disturbance of the streambed does not occur.

Water quality in the Flathead drainage can be expected to continue to deteriorate due to the failure of present methods used to control water pollution from the following sources:

Source	Major Pollutant(s)
1) Municipal Sewage	nutrients (esp N and P)
2) Individual sewage systems	nitrogen ions
3) Irrigation return flows	nutrients, salts
4) Livestock wastes	nutrients, organic carbon
5) Wood wastes and industrial ground water discharges	phenols
6) Timber management practices	sediments, streamflow & temp. modifications
7) Watercraft	organic carbon

The first four sources are the most critical with regard to aquatic productivity. The number and usage of individual sewage systems is believed to be increasing at a rate much faster than other pollution sources, but farming and livestock appear to be the major sources of nutrient enrichment.

SECTION IV

Summary and Conclusions

A summary of nutrient inputs from cultural activities believed to be entering Flathead Lake from the Flathead River are presented below (Table 8).

Table 8. Estimates of nutrient inputs into upper Flathead River.

Source	Nitrogen (lbs)	Phosphorus (lbs)
Municipal Sewage[1] (Kalispell, Whitefish, Columbia Falls)	107,000	30,000
Agriculture		
Farming[2]	1,450,000	34,000
Livestock[3]	300,000	60,000
Individual Sewage[4]		
Systems	200,000	Minor
Timber Management[5]	Minor	Minor
Total Cultural Inputs	2,057,000	124,000
Estimate of Total Nurtient[6] Flow in Upper Flathead River	3,844,000	2,042,000
Estimate of Natural Occurring Nutrient Flow (Total - cultural Inputs)	1,787,000	1,918,000
Percent Increase Caused by Cultural Inputs (Cultural/Natural)	115%	6.5%

Assumptions:

1. Municipal sewage use = 11,000 persons. Removal efficiency = 10% personal equivalents = 7 lb/person/yr N, 2 lb/person/yr p
2. As explained in Agriculture section, no correction factors for Swan drainage or areas around Flathead Lake. No correction for lag time for groundwater to surface/water enrichment.
3. As explained in Livestock section, no estimate of groundwater enrichment included.
4. No lag time for groundwater movements to surface waters. McGauhey, Dugan and Porcella (1971) determined the ratio of

nitrogen to phosphorus pollution from this source to be 714/1. Phosphorus inputs therefore estimated to be about 300 lb.

5. Natural nutrient loss from the forest ecosystem in Montana is unknown. Utilizing figures from Cole and Gessel (1965) and assuming 10,000 acres/yr disturbed soil mat, estimates of 4,000 lb nitrogen and 700 lb of phosphorus are obtained. However, long-term effects and climatological variables prevent any sort of realistic estimate.
6. From U. S. Geological Survey water quality data of Flathead River near Bigfork 1970 monthly samples of nitrogen (NO_3-N, NH_4-N, and Organic N) and total phosphorus averaged and calculated with average monthly discharge.

The validity of these estimates are regretfully questionable. Most figures are mean averages of estimates with extremely wide ranges. While individual inputs from the sources are believed realistic, the assumption of no lag time between the enrichment of groundwaters and discharge to surface waters may be a considerable error. The absence of estimates of groundwater enrichment from livestock wastes may be a serious omission of nitrate pollution.

Other forms of water pollution that cannot be assessed in this manner include: increased thermal modifications by clearcuts and reservoir operation; increased sedimentation caused by timber management, roads, and agriculture; organic carbon pollution from motorboats, livestock, woodwastes, and municipal sewage; and phenols, lignens and tanins from woodwaste disposal.

Perhaps the most serious pollutant of the above is organic carbon. Ruttner (1963) reported that investigations of lakes in Wisconsin found eutrophic lakes to contain 12.5 mg/l organic carbon, whereas oligotrophic lakes had a content of about 5 mg/l organic carbon. U. S. Geological Survey data (1970) for the Flathead River near Bigfork revealed an average of about 3 mg/l total organic carbon. Livestock appears to be by far the largest contributor or organic carbon to the Flathead system. Data obtained by Robbins, Howells, and Kriz (1971) applied to Flathead livestock statistics result in an estimate of over 1.8 million pounds of organic carbon contributed yearly to the Flathead drainage. Municipal sewage may contribute over 250,000 lbs yearly, while motorboat wastes contribute perhaps 160,000 pounds per year.

Nutrients critical with regard to eutrophication have yet to be identified. Extensive research has been undertaken to resolve this international problem. The conclusions of these studies, plus data synthesized for this study yield some insights in determining the critical growth factors for the Flathead drainage.

Thomas (1969), speaking of European lakes, has stated, "It is certain, moreover, that oligotrophic lakes on which man has had little or no influence all have phosphate as the limiting factor; free nitrate ions were present in these lakes throughout the year. Elimination of sewage nitrate in these cases, therefore, would be useless."

"To avoid algal damage in lakes, we need to reduce the supply of phosphates."

Edmonson (1972) reached a similar conclusion for Lake Washington, near Seattle:

"It is clear that phosphorus has had a central role in the control of productivity of the lake as expressed by the abundance of phytoplankton."

McGauhey, Dugan and Porcella (1971) determined that Lake Tahoe was nitrogen sensitive, and responds in proportion to the concentration of this nutrient. However, the study found the average ratio of nitrogen to phosphorus (N/P ratio) of Tahoe waters to be 2.08 while citing Fencl (1963) as having determined the N/P ratio for algal cells to range from 6.9 to 18. This would indicate an excess of phosphorus in Lake Tahoe waters.

Powers, Schults, Malveg, Brice and Schuldt (1972) found that pristine Waldo Lake in Oregon would respond with algal growth when phosphorus or phosphorus plus nitrogen were added to the lake waters, but showed no response to nitrogen or carbon alone.

Winning (pers. comm.) believes phosphorus to be the limiting growth factor in Lake McDonald in Glacier National Park.

Our synthesized data indicate that nitrogen inputs to Flathead Lake have doubled, while phosphorus input has increased between 5 to 8%. Increased productivity, while not determined, is certainly not believed to correspond to the nitrogen increases.

The literature and available information on the Flathead drainage support the statements of Thomas (1969). Oligotrophic lakes in temperate climates appear initially to be phosphorus limited. Once critical levels of phosphorus are reached, the additions of other nutrients, such as nitrogen or carbon, then cause increased productivity. Our data, while certainly not conclusive, supports the hypotheses that the productivity of Flathead Lake is phosphorus, or phosphorus plus nitrogen limited. Nitrogen alone is not believed a critical factor and control measures specifically designed to control nitrogen ions in an effort to abate potential eutrophication of Flathead Lake appear unwarranted. The major sources of phosphorus; livestock, farming, and municipal sewage, should receive special attention. Proper land management practices suggested for the agriculatural sources, as suggested in Section I of this report, should be immediately implemented as the costs of these changes in land management are believed minimal. Tertiary treatment specifically designed for removal of phosphorus from municipal sewage, should be studied for cities in the upper Flathead drainage. As contributions of phosphorus from minicipalities other than Kalispell are currently small, seasonal spray irrigation facilities, for these minicipalities might be installed that could be of agricultural benefit.

Flathead basin lakes that are moderately eutrophic, such as Lake Mary Ronan and Echo Lake, may contain phosphorus concentrations well above those levels where phosphorus is limiting. Hence, nitrogen or carbon inputs may now directly increase productivity. Removal of phosphorus inputs, then, would not show result in a reduction of productivity for that period where phosphorus levels, though reduced, remain above critical levels. Hence, these lakes should initially attempt to control all nutrient sources. Perhaps at a later date, then, one critical factor may be specifically controlled.

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Appendix I

Information adapted from:

"Tentative proposals for maintaining fish and wildlife habitat in the Upper Flathead Drainage," presented by Robert Schumacher to a meeting of the Columbia North Pacific Inter-agency Committee at the University of Montana Biological Station at Yellow Bay on Flathead Lake.

18 September, 1972.

Habitat Preservation for the North Fork, Flathead River

This is one of the two remaining free-flowing forks of the Flathead River whose tributaries constitutes better than 95% of the total spawning and nursing area for the native westslope cutthroat trout and Dolly Varden trout that populate the 125,000 acre Flathead Lake and Tributaries waters. Any loss of gravel habitat will result in a smaller harvestable sport fish population as the quantity of suitable nursery area is believed to be the populations limiting factor. Habitat Preservation will have to be concerned with the following:

1. Maintain North Fork free-flowing with no obstructions to fish passage.
2. Maintain tributary and main stream water temperature and chemistry most suitable for cutthroat trout.
3. Minimize erosion from road construction and timber harvesting.
4. Maintain migrating fish passage routes.
5. Insure channel stability below culverts or bridges.
6. Insure bank stability recognizing channel capacities and vegetative cover.

The major concerns of habitat preservation in North Fork waters in addition to preserving it as a free flowing river will be mostly involved with land management policies of the U.S. Forest Service, Montana Department of Forestry and the road construction activities of these two agencies plus the Flathead County Road Department, Montana Highway Department and to some extent the Federal Highway Administration. Some private lands more immediately adjacent to the North Fork may become problems in habitat abuse if they are exploited commercially into housing developments.

Policy statements from the government agencies would be a first step in assuring that their management plans would recognize the aquatic habitat preservation and provide the necessary guideline for their action programs. Implementation of County zoning laws concerning housing development would insure pollution control from these potentially detrimental areas. The possibility of habitat destruction by coal mining would be reduced by the Strip Mining Act in Montana. The potential for considerable damage exists from mining coal deposits on the Canadian port of the North Fork. Control would likely only be possible by treaty or by jaw-boning and bad press releases.

Fresh cutting practices destroy wildlife habitat when large open areas are created, when clearcut areas cause winter snows to get too deep and where security cover is removed causing game animals to avoid being exposed either in migration or feeding activities. Reduction in clear-cut sizes leaving strips of cover in connecting runways and avoiding calving and winter range areas with roads would do much to preserve game habitat.

Habitat Enhancement for the North Fork, Flathead River

The aquatic habitat has suffered from roads located on potential land mass failure areas, especially adjacent to trout streams. Frequently culverts were installed in place of bridges and have caused channel instability, erosion, and fish passage barriers. These are mainly on state and federal forest lands and with some occurring on private holdings. Such structures should be replaced with adequate timber bridges. A survey of problems caused by culverts should be made and reconstruction planned. The plan should provide a schedule of the reconstruction work.

Stream braiding and channel instability has occurred following timber sales on some North Fork tributaries. Resulting deposits of downed timber slash and debris have caused some barriers to fish movement, bank erosion and water pollution from silts and sediments. A survey by Forest Service personnel should include the number of problems and estimated man days to correct them.

Seeding exposed soil on road cuts and fills and using hand-cleared fire brakes downhill instead of using bulldozers would enhance aesthetic appearance of ugly road scars and reduce erosion.

Instream Water Requirements for the North Fork, Flathead River

Formula must be developed to determine the percent of mean flows which would minimumly meet the needs of trout during two seasons of the year. During flood flows some level of high water is necessary to reach the full nursery habitat. Data being obtained under West Wide Water Study is expected to allow projection of minimal needs.

Preliminary figures being subjected to tests are for 30 percent of the daily mean flow for October 1 through March and 60 percent of the daily mean flow from April 1 through September.

Management of Public Access for the North Fork, Flathead River

Considerable land areas immediately adjacent to the North Fork are in private holding. The river flows through 25 sections of land on the west bank that are in private hands and through 17 sections under Federal or State management. The east bank is in Glacier National Park where present policies are to restrict further access by limiting road building within the park. Access to most tributary streams outside the park are possible by motor vehicle. Four out of the ten major North Fork tributaries are closed to fishing all year as a means of protecting spawning and nursery streams for the migratory Dolly Varden (Bull trout) and westslope cutthroat trout. Lakes in this tributary system are open to fishing. Also as a means of further protecting the Dolly Varden, a minimum size limit of 18 inches is enforced.

Land should be acquired and developed for one additional campground in the Polebridge area and two day-use access areas for shore angling and the launching of small boats.

Management of Harvest for the North Fork, Flathead River

Fish and Game harvest is regulated by orders of the Fish and Game Commission within the framework of Montana Statutes. Limits for game fish are quite liberal and have remained constant in the area for the last ten years. Fishing pressure estimates for the North Fork alone were 9,278 man days per year while tributaries that are open to fishing receiving about 200 man days each. The four of the larger North Fork tributary streams are closed to fishing. Study should be conducted to determine if these closures cause these streams to make any greater contribution to the young down-stream migrants. The Dolly Varden also is protected by an 18 inch minimum size limit. This regulation also should be studied in detail to determine if the restriction is asserting the Dolly Varden to maintain itself or if harvestable fish are being lost.

Greater use could be made of the mountain whitefish but more liberal limits and seasons have not accomplished this. A very generous angling and snagging season for kokanee causes good utilization of that species.

Big game is not particularly abundant in the North Fork Area due to very limited winter range and areas of deep snow.

Artificial Propagation for the North Fork, Flathead River

Needs for artificial propagation of fish for the North Fork waters would primarily be for the initial introductions of fish into waters where migrating fish have not had access in the past. These areas include the high mountain lakes and stream areas above natural barriers. Other needs would be to reestablish spawning runs into waters where man-made obstructions have obliterated previous runs. Stocking of migratory fish as a put-and-take fishery does not generally provide a successful fishery unless the fish are constrained in their movement by weirs and dams.

Habitat Preservation for the Middle Fork, Flathead River

This is one of the two remaining free-flowing forks of the Flathead River which, with their tributaries constitutes better than 95% of the total spawning and nursing area for the native westslope cutthroat trout and Dolly Varden trout that populate the 125,000 acre Flathead Lake tributaries waters. Any loss of gravel habitat will result in a smaller harvestable sport fish popluation as the quantity of suitable nursery area is believed to be the populations limiting factor. Habitat preservation will have to be concerned with the following:

1. Maintain Middle Fork free-flowing with no obstructions to fish passage.
2. Maintain tributary and main stream water temperature and chemistry most suitable for cutthroat trout.
3. Minimize erosion from road construction and timber harvesting.
4. Maintain migrating fish passage routes.
5. Insure channel stability below culverts or bridges.
6. Insure bank stability recognizing channel capacities and vegetative cover.

Major habitat preservation will be concerned mainly with governmental agencies. Policies of the electrical companies and controlling agencies, U.S. Forest Service, Montana and Flathead County Highway Departments, Federal Highway Department plus private landowners will determine if the environmental quality of the Middle Fork will be upheld. Policy statements from agencies and large companies should be obtained stating to what degree they recognize quality management of the fish and wildlife and water quality resources as important for the well-being of the area, the state and the human population. From these statements guide lines should be developed by the agency or company concerned.

Roads should avoid winter range and calving areas. Winter range is about the most critical aspect in Big Game survival in areas where winters are very long and severe.

The U.S. Forest Service should survey and prepare a report on all culverts and bridges giving in each case a satifactory or unsatisfactory status as far as causing erosion, or being passable to spawning game fish. The Federal, State, and County Highway Departments should make the same type of survey and report.

All construction of roads, railroads, power lines and all timber removal must protect streams against summer changes in water temperature by maintaining vegetative cover adquate in height and density to provide shade to the stream during the summer sun angles.

Stream banks must be protected against operating equipment to avoid compacting, bank sloughing and vegetative distrubance which is essential to prevent bank erosion.

Habitat Enhancement for the Middle Fork, Flathead River

Parts of the Middle Fork have much less snow depth and better exposures than most of the North Fork, thus resulting in more favorable winter range for both elk and deer. Preservation of this wildlife habitat should be a prime consideration in future road building and timber harvest designs.

The U.S. Forest Service should be asked to determine the amount of potential winter range for elk and deer in the area where they still have management options. Timber harvest and fire control could be useful tools in developing additional winter range.

A survey of bridges and culverts on tributary streams should be made by Forest Service, State and County Highway Departments. The evaluation of the culverts to pass fish should be made by a fishery biologist. This can be done by field surveys in specific site locations described in as being questionable or from physical measurements provided him. These measurements should include culvert diameter, culvert length, stream gradient above and below culvert area -- culvert gradient, height of outfall, and deposition of bed load above culvert.

A reconnaissance should be made of major tributaries to determine if there are many barriers to fish migration caused by debris blocking streams from fires. A plan to remove such barriers should be developed and carried out.

Instream Water Requirements for the Middle Fork, Flathead River

Formula must be developed to determine the percent of mean flows which would meet the minimum needs of trout during two seasons of the year. During flood flows some level of high water is necessary to reach the full nursery habitat. Data having obtained under West Wide Water Study is expected to allow projection of minimal needs.

Preliminary figures being subjected to tests are for 30 percent of the daily mean flow for October 1 through March and 60 percent of the daily mean flow from April 1 through September.

Management of Access for the Middle Fork, Flathead River

Much of the Middle Fork is in either a roadless area or has a Wilderness designation. Above Bear Creek near the Java Ranger Station, the main river flows through 37 sections and is fed by 12 major tributaries in the roadless area. This roadless area is now a candidate study area for possible Wilderness designation. Access by other than foot or horseback will be the only means of getting into the area and is not likely to be greatly increased during the study period or in wilderness designated areas. This area is all under U.S. Forest Service Administration.

Some consideration should be given to priorities and aesthetics in trial system use or development. Foot trails can be laid "easier-on the land" than horse trails and have less environmental impact. Many foot trails could be developed in closer contact with the river to allow angler access without environmental harm. Some foot trails could connect corrals and streams thus reducing horse trail impact on more fragile areas.

Access into the middle of the roadless area and within three miles of the Bob Marshall Wilderness is now possible by small aircraft. A landing field at Schaffer Meadows will be closed to use if this candidate study area becomes wilderness. This airfield is used both in hunting and fishing. Many "float trips" in rubber rafts originate at the airfield and traverse the roadless area to Bear Creek.

Access on the Middle Fork below Bear Creek has some seven sections of private land and 20 sections of public land on the west side of the river. The east side in this area is all part of Glacier National Park. Portions of the park are in a Wilderness candidate study area also but access has been previously restricted to foot or horse travel in most of this area in the past.

Management of Harvest for the Middle Fork, Flathead River

Fish and Game harvest is regulated by orders of the Fish and Game Commission within the framework of Montana Statutes. Limits for game fish are quite liberal and have remained constant in the area for the last ten years. Fishing pressure estimates for the Middle Fork were 6,435 man days and tributaries that are open to fishing probably had less than 100 man days due to restricted access. The four of the larger Middle Fork tributary streams are closed to fishing. Study should be conducted to determine if these closures cause these streams to make any greater contribution to the young down-stream migrants. The Dolly Varden should be studied in detail to determine if the restriction is asserting the Dolly Varden to maintain itself or if harvestable fish are being lost.

Greater use could be made of the mountain whitefish but more liberal limits and seasons have not accomplished this.

Habitat Preservation for the South Fork, Flathead River

Below Hungry Horse Dam there is only limited opportunity for habitat preservation, one exception would be to zone against stream bank or bed alteration. One realtor plans to develop a campground with fish ponds, trailer spaces, etc., right on the river flood plain near the mouth of the South Fork River. Increases in minimal flows controlled by the Bureau of Reclamation generation at 160 cfs should be increased to 350 cfs.

Habitat Preservation in the reservoir area should deal with amount of total annual draw-down and also the length of the year which draw-down is affecting the fish habitat. Draw-downs occur annually for power generation and flood control storage. Schedules and recommendations for draw-down should be programmed to cause the least habitat degradation compatable with flood storage base on snow pack information. In 1970-71, maximum draw-down was 119' and the reservoir was at full pool for less than a month. At 119' draw-down, the reservoirs surface inundates only a small fraction of the area it would at full pool. Insects, plants, and periphyton living in the lake bottom are at least partially destroyed and the productivity area is put completely out of production after having just a few weeks of "summer growing season". Recently power demands have caused draw-downs to commence August 15 to September 1. There is no flood problem that demands that the total storage be available before April 1st. Delayed draw-downs would greatly increase the "growing season".

The aquatic habitat should be protected from accumulations of bark and chemicals leached from both when logs are rafted and floated in the reservoir.

Road construction and timber sales must be refined to be non-degrading of the aquatic habitat. Road building and stream crossings should be held at an absolute minimum. The system need not be designed so all drainages are inter-connected with loop roads. All streams should be protected against these six critical habitat problems:

1. Maintain South Fork free-flowing with no obstructions to fish passage.
2. Maintain tributary and main stream water temperature and chemistry most suitable for cutthroat trout.
3. Minimize erosion from road construction and timber harvesting.
4. Insure channel stability below culverts or bridges.
5. Maintain migrating fish passage routes.
6. Insure bank stability recognizing channel capacities and vegetative cover.

The South Fork and tributaries above the reservoir are important spawning and nursery areas for the Dolly Varden and cutthroat trout. A study should be made to determine if cutthroat and Dolly Varden from the reservoir are able to migrate past the high velocity flows in a narrows on the South Fork known as Meadow Creek Gorge. Although it is suspected that the Dolly Varden can negotiate the obstacle there is no positive tagging and recovery data to indicate that either species can make it through on their spring spawning runs which coincide with high water flows.

Habitat Enhancement for the South Fork, Flathead River

There are culverts on both the main Forest Service haul roads and logging roads that are completely impassible to fish with many causing serious erosion problems.

A survey reconnaissance of all roads crossing permanent stream tributaries to the reservoir or South Fork river should be made. A report should be prepared detailing culvert length, diameter, stream gradient above and below culvert, culvert gradient and height of outflow. Problem culverts should be inspected by a fishery biologist and Forest Service personnel to prepare a plan on the extent of replacement or modification found necessary to provide fish passage or to maintain water quality standards.

Management of Access for the South Fork, Flathead River

Downstream from the Wilderness boundary to the junction of the main Flathead, access is very adequate. In fact, access is too great for benefit of migrating and calving elk herds. In the future many side roads should be closed to vehicular hunting traffic to reduce the road hunting and to spread the harvest among the ever increasing hunters. Some restriction of winter over snow vehicles may also have to be enacted to reduce winter harassment when animals are in jeopardy due to cold, deep snow and high body energy requirements.

Within the Bob Marshall Wilderness travel is restricted to non-vehicular, non-motorized equipment. Travel by horse or foot trail can get one to all the major sections of the Wilderness. There are many areas without marked or improved trails and will probably remain that way. Wilderness users have increased to the extent that a true wilderness experience is frequently impossible due to the repeated contact with other people. Further increase of use will require a policy of requiring reservations for group travel which would limit party size and routing schedules. Tentative regulations are now being drafted by the U.S. Forest Service.

There are nine campgrounds on the reservoir or South Fork River outside the Wilderness area. Five are equipped with boat launching areas that are usable during full pool. (July 10 - August 30 the last few years) It is nearly impossible to get a boat into the reservoir after the draw-down exceeds 25 feet.

Management of Harvest for the South Fork, Flathead River

Restricted access and the length of the hunting and fishing seasons provide management tools to regulate the harvest. The Bob Marshall Wilderness is not on a quota system for deer, elk or bear. Further harvest control is available through drawings for restricted numbers of permits when harvest trends, winter browse conditions and herd conditions warrant that type of control.

Fisheries regulations are quite liberal and angler pressure doesn't justify further restriction at present. Data gathered on fish populations indicate the potential for a considerable increase of harvest by a better distribution of anglers. This does not mean more access but as angler success rates decrease, anglers will get further off the beaten trails where harvest is negligible.

Artificial Propagation for the South Fork, Flathead River

Spawning and rearing habitat is well utilized in all areas to which fish have access. River and reservoir populations are believed to be at or near carrying capacities although population size is controlled by the carrying capacity at the most critical time of the year, the minimum pool habitat at maximum draw-down levels. Artificial stocking is done on some high mountain lakes which do not have available trout spawning areas. Some introductory stocking has been done and will continue for streams where natural barriers had prevented naturally established populations.

Instream Water Requirements for the South Fork, Flathead River

A formula must be developed to determine the percent of mean flows which would meet the minimum needs of trout during two seasons of the year. During flood flows some level of high water is necessary to reach full nursery habitat. Data being obtained under West Wide Water Study is expected to allow projection of minimal needs.

Preliminary figures being subjected to tests are for 30 percent of the daily mean flow for October 1 through March and 60 percent of the mean flow from April 1 through September.

Habitat Preservation for Flathead Lake, Swan Lake and Tributaries

Fisheries habitat preservation of Flathead and Swan Lake depend almost entirely on the free-flowing tributary streams where all cutthroat, Dolly Varden and rainbow trout, mountain whitefish and to a large extent kokanee salmon are naturally propagated. Water quality has to remain non-degraded in chemical purity, free from silt and debris, and of suitable temperature or the fishery of the entire river and lake system will collapse, with the possible exception of lake trout and lake whitefish.

Regulation of Hungry Horse discharge during fall spawning season would give control over kokanee salmon spawning success and subsequent size of the mature salmon four years later as this species size is density dependent.

Regulation of the Flathead Lake levels is a factor in the success of lakeshore spawning kokanee, as well as perch and bass in the Polson Bay area. Maximum draw-down is now is now restricted to ten feet, partially by agreement with landowners and partially by restrictions in the outlet channel above Kerr dam. Habitat Preservation demands that outlet channel clearance not be considered favorably. Such fluctuations destroy the productive area or "pasture" area of the lake, the greater the draw-down, the greater the total reduction of food producing area. In a lake basin as low in basic fertility as this system its growth of resident fish would suffer to an unacceptable extent.

Swan Lake is subject to the same low fertility and short summer growing seasons as Flathead Lake. The lake has suffered from poor fishing since the Swan River Dam was built at Big Fork which was built without a fish ladder. Years later a fish ladder was constructed but considered inefficient. The ladder was modified in 1963 but has not been effectively tested as no migratory cutthroat trout were planted in tributaries above the dam and lake to attempt to reestablish the migratory runs. Cutthroat trout fry were planted in more than twenty Swan River tributary streams in 1967 and 1968 in an attempt to reestablish migratory cutthroat that would utilize a fish trap during the spring migration in 1971 and 1972, but was poorly used with less than a half a dozen cutthroat collected in the trap.

Swan Lake outlet can not be altered without adversely effecting the ecological relationships of the lake and its game fish population. It would be better to remove the Pacific Power and Light dam which already is an ecological misfit and doesn't produce much more than enough electricity to pay for the supervision and maintenance.

Tributary streams of Swan River are in heavily forested lands. Low lands with good timber were partially cut in the 1930's and 1940's. In the last decade, many timber sales have been made and many of them have been large clearcuts. The land ownership is a checkerboard pattern in the Swan Valley with the large private holdings by Burlington Northern Railroad, owned previously by Anaconda and now by Champion Plywood, the U.S. Forest Service, and Montana State Forest are the other large landowners.

Habitat preservation is critical when adjacent sections are in various ownerships. Habitat degradation has been frequently blamed on "the other guy". Game habitat has suffered by clear cutting large areas of winter range for elk and whitetail deer. Many small woodland ponds were clearcut to the edge completely destroying wildlife habitat for many smaller animals and waterfowl.

Strips of cover and timber should be left between timber sales until cover is adequate on the cut areas. Timber strips following natural draws and water courses serve both as avenues of travel for big game and protection of the stream bank and shade to minimize stream warming.

A cooperation agreement should be signed between the U.S. Forest Service, State Forestry Department, Burlington Northern, and Champion Plywood (Anaconda) to effect a joint effort and responsibility in their timber management. In any drainage, consideration must be given to the other owner's harvest plans, roads, etc. in order that peak run off doesn't exceed channel capacity, that too much forest cover isn't disturbed at one time and general overall benefits to all landowners can accrue.

Habitat Enhancement for Flathead Lake, Swan Lake and Tributaries

A survey of all culverts and bridges on the Swan River tributaries should be made to determine probability of fish passage during spawning runs and if they are causing erosion. Reports on culvert length, diameter, stream gradient above and below culverts, and culver grade, the outfall drop and the amount of bedload deposited above the culvert site.

Fish and Game has 21 stream gauging stations on Swan River and tributaries on which water temperature and chemical water quality are being monitored periodically. Data will be used to evaluate quality of trout habitat and rates of change in quality.

Road cuts and fills should be seeded as soon as constructed to reduce erosion and the amounts of silt entering the stream. Trees should be felled away from streams to minimize the amount of debris and limbs entering the stream. Some additions or enhancement can be made to winter game range, especially for elk and deer. Controlled burns on browse plants that have either grown out of reach or that are in a dormant stage can cause resprouting and increase the food production on critical winter range. Some timber sales might enlarge winter range if located on favorable south and west facing slopes in areas with the appropriate aspect slope and snow depth.

Removal of some debris caused by "cedar" timber sales on trout streams would improve streams that were once quality spawning areas.

Habitat enhancement can frequently be obtained by population control of undesirable non-game fish species; such as perch, squawfish, sunfish and suckers. The first three species are predacious on small trout, cause trout mortalities when partially swallowed and their spiny fins prevent rejection. All the species are competitors for food space and in some cases, spawning areas. Populations can be controlled with chemical fish toxicants that are biodegradable. The control works especially well in small to medium sized lakes and to some extent in rivers. Control measures frequently need repeating from annual treatment in some streams, to periods of seven to ten years in closed lakes systems.

Instream Water Requirements for Flathead Lake, Swan Lake and Tributaries

A formula must be developed to determine the percent of mean flows which would meet the minimum needs of trout during two seasons of the year. During flood flows some level of high water is necessary to reach the full nursery habitat. Data being obtained under West Wide Water Study is expected to allow projection of minimal needs.

Preliminary figures being subjected to tests are for 30 percent of the daily mean flow for October 1 through March and 60 percent of the daily mean flow from April 1 through September.

Management Access for Flathead Lake, Swan Lake and Tributaries

Road systems traverse nearly everywhere in the Swan Lake and River basin except into the wilderness or on steep slopes. Some road closures have been made for big game habitat enhancement and more will be necessary. A survey should be made of logging roads and spur roads that could be closed to benefit quality game habitat management without adverse effect on other resources used. Access is available to streams on all government forest lands for hunting and fishing. The position which the new owner of Anaconda lands will take is unknown.

Access to Swan Lake is limited, one campground and boat launching area exits on the south end. A campground and boat access on the north end of the lake is desirable. Access to the main Swan River is becoming more restricted as segments of river front are being acquired for home sites or summer homes.

Access to Flathead Lake is quite adequate with seven State Parks with boat launching ramps, one State boat access area and one National Forest campground.

Management of Harvest for Flathead Lake, Swan Lake and Tributaries

Fishing pressure estimates for Flathead Lake are more than 65,000 man days, Swan Lake 5,064 man days, Swan River 9,940 man days plus over 1,000 man days on larger Swan tributaries. Numerous high mountain lakes in the wilderness area support unknown, relatively small, amounts of pressure.

Angling limits are generous but angler capacities and the time of the year are more restrictive than the fish populations or regulations. Dolly Varden are restricted by a minimum size limit of 18 inches total length. Larger game fish are protected to the extent that a ten-pound plus one fish limit constitutes a limit of larger fish.

Artificial Propagation for Flathead Lake, Swan Lake and Tributaries

Flathead Lake populations of kokanee salmon are egg sources for stocking most waters where kokanee reproduction is not successful. Eggs taken by Somers Hatchery crew from the main river, Swan River and Flathead Lake are hatched at the station to the fry stage and planted. The Somers Hatchery is antiquated and has an inadequate water supply. It or an alternate hatchery should have capacity for hatching 6,000,000 salmon eggs, raising 600,000 cutthroat to 3 to 4 inches annually plus 150,000 cutthroat to a size of 6 inches annually. In addition, it should have brood fish holding capacity for 10,000 pounds of mature stock.

This capacity would meet the needs for all westslope cutthroat in Region One including all the Flathead River system except Flathead Lake. This would also meet the needs of the Kootenai River drainage, except for Libby's Koocanusa Reservoir.

Any dams constructed on the main Flathead River tributaries would have to carry mitigative costs to stock a minimum annually of an estimated 1,000,000 pounds of cutthroat and other trout species to minimally sustain the main lake and the main tributaries.

The Creston Hatchery operating at full capacity uses nearly all its product to produce fishing on Indian Reservations. Further expansion potential is questionable.

The Jocko River State Hatchery at Arlee, Montana is operating at field capacity now with little room for potential expansion. The entire State's rainbow brood trout are raised here. Eggs taken and partially incubated are then distributed to the other state hatcheries.

Libby mitigative moneys have been promised during the whole construction and preconstruction program. Nothing has materialized except suggestions that the State keep going back to Congress seeking adequate funds to finance and operate a hatchery with the productive capacity of 30,000 to 50,000 pounds of cutthroat trout exclusively for Lake Koocanusa.

Acquisition of Wetlands for Waterfowl for Flathead Lake, Swan Lake and Tributaries

Lands are being acquired for refuge and waterfowl management areas with approximately 5,000 acres in Flathead County, 6,430 acres in Lake County and 2,900 acres in the Swan River Drainage. A collective total of 14,330 acres will ultimately be acquired. Water will be held in pools by dikes, courtship and resting areas will be built as well as nesting islands. A portion will be managed as a hunting area during the open seasons.

Improvement of Fish Passage to Swan Lake

The only worthwhile recommendation would be to remove the dam and discontinue the small inefficient generating plant rather than to spend more money to provide questionable improvement to the existing questionable fish ladder.

Habitat Preservation for the Lower Main Stem, Flathead River

The enactment of County zoning laws which would control development on the flood plain needs laws to prevent stream channel alteration by individuals. Feed lot regulations are needed to preserve the aquatic habitat where drainage enters streams or lakes and control sediments from irrigation returns which are now exempt from the state pollution laws.

Habitat Enhancement for the Lower Main Stem, Flathead River

Cattle grazing on the stream bank yields erosion and causes stream sediments. Cattle should be fenced from lakes and streams and water piped to livestock. The amount of fencing and cattle guards necessary to protect the streams should be made along both sides of the Stillwater, Whitefish, Swan and Main Flathead Rivers below Columbia Falls.

Grass and non-noxious plants should be left on irrigation ditch banks and fenced which would provide wildlife cover and nesting areas.

Habitat enhancement can frequently be obtained by population control of undesirable non-game fish species; such as perch, squawfish, sunfish and suckers. The first three species are predacious on small trout, cause trout mortalities when partially swallowed and their spiny fins prevent rejection. All the species are competitors for food space and in some cases, spawning areas. Populations can be controlled with chemical fish toxicants that are biodegradable. The control works especially well in small to medium sized lakes and to some extent in rivers. Control measures frequently need repeating from annual treatment in some streams, to periods of seven to ten years in closed lakes systems.

Instream Water Requirements for the Lower Main Stem, Flathead River

A formula must be developed to determine the percent of mean flows which would minimumly meet the needs of trout during two seasons of the year. During flood flows some level of high water is necessary to reach the full nursery habitat. Data being obtained under the West Wide Water Study is expected to allow projection of minimal needs.

Preliminary figures being subjected to tests are for 30 percent of the Daily Mean Flow for the period October 1 through March and 60 percent for the period April 1 through September.

Management of Access for the Lower Main Stem, Flathead River

Public access points and boat launching areas on the Flathead River from Columbia Falls to Flathead Lake total six in some thirty miles of river. Access to the Stillwater or Whitefish Rivers is almost nil south of Whitefish, Montana. Small access acreages should be acquired on both of these rivers.

Management of Harvest for the Lower Main Stem, Flathead River

Game and Fish regulations are adequate at present and are sufficiently flexible to allow changes. Fishing regulations are quite liberal with bonus limits for extra abundant species like the mountain whitefish and salmon. Snagging seasons for salmon recognize they die after spawning and utilization of all but necessary brood fish is desirable.

Restrictions on Grazing for the Lake Mary Ronan and Little Bitterroot Lake Areas

A cooperative agreement should be sought between the U.S. Forest Service, Montana State Forest Department, Burlington Northern and Champion Plywood to establish grazing quotas in mixed landownership areas. Animal grazing months can be calculated and prorated for all cattle in the area. Where cattle grazing is a serious detriment to other resources, particularly water, reduced grazing should be done. The grazing fees do not pay for loss of quality water.

Appendix II. Phytoplankton Identification and Distribution in Flathead Lake (Morgan 1970)

Discussion of Flora. Dr. Moghadam (1969) in her systematic study of the diatom communities of Flathead Lake identified 337 different taxa of which five species and two varieties were new. During the period covered by this study, a total of 199 species and varieties was identified. Five divisions of algae were encompassed in this numeration. Delation of species common to both studies yields a combined total of 503 different species and varieties of algae found in Flathead Lake's phytoplankton population. *Dominant species of Chrysophyta*. The planktonic algae which exhibited dominance throughout the study are almost entirely of the sub-division Bacillariophyceae. The genera most frequently encountered are: *Asterionella*, *Fragilaria*, *Rhizosolenia*, *Synedra*, and *Tabellaria*, with occasional appearances of *Cyclotella*, *Navicula*, *Cymbella*, *Campylodiscus*, *Surirella*, *Gyrosigma*, and *Eunotia*. Other algae encountered frequently of the same division, Chrysophyta, sub-division Chrysophyceae, were four species of the same genera: *Dinobryon bavaricum* Imhof, *D. divergens* Imhof, *D. sertularia* Ehrenberg, and *D. sociale* Ehrenberg. Other genera of the same sub-division were *Mallomonas*, *Rhizochrysis*, and *Synura*. The latter three genera occurred less frequently and are listed in their order of frequency. The total number of species identified in the order Chrysophyta was 109.

The *Cyanophyta* or blue-green algae most often found were *Chroococcus*, *Gomphosphaeria*, *Gloeocapsa*, *Microcystis*, *Meriamopedia* and on occasions *Spirulina*, *Anabaena*, *Aphanocapsa* plus *Aphanizomenon*. *Aphanizomenon* occurred one time only in the phytoplankton of Flathead Lake. The blue-green algae did not exhibit any dominancy except for one bloom of *Aphanizomenon flos-aquae* Ralfs in late summer. The bloom occurred just to the west of Bigfork Bay. This area is relatively shallow (2-8m) and is exposed to the diurnal mixing action of the south wind. The continual eddying returns the nutrients from the sediments to the water above for algal utilization.

The blue-green algae occurred most frequently in the late summer and early fall when the nutrients were at their lowest concentrations. *Chroococcus* *limnetica* Lemmermann, *C.* *Prescottii* Drouet & Daily, and *Aphanocapsa* *elastista* G. M. Smith are the most common species found in the pelagic zone of the lake.

A total of 25 species was identified during the study of which 10 are rather rare in occurrence. Genera, such as, *Dactylococcus*, *Eucapsis*, *Gloeotrichia*, *Lyngbya*, and *Synechococcus* appear rarely and then only in limited numbers.

The division Chlorophyta (green algae) are even less frequently found in the planktonic samples of Flathead Lake. *Oocystis* spp. are the most frequent, followed by *Spaerocystis*, *Cosmarium*, *Pediastrum*, and *Staurastrum*. *Dictyosphaerium* *pulchellum* Wood is often found in samples containing *Chroococcus* spp. during the late summer months. The remaining species are infrequent and most times are transported from areas along the shoreline or rivers to the pelagic region of the lake. Filamentous species, such as, *Mougeotia* *genuflexa* (Dillw.) *Zygnema* *pectinatum* Fritsch & Stephens represent transported species. These species are sessile forms commonly found along the shore areas.

Sixty-three different species were found in the plankton samples during the study.

The small division Pyrrophyta was well represented with five genera and 14 species. Most commonly encountered were the species *Ceratium* *hirundinella*, *Glenodinium* *KulcZynskii* (Wolosz.) *Schiller*, and *Peridinium* *cinctum* var. *tuberosum* (Meunier) Lindeman. This division is limited in numbers during the spring. The increased temperatures of summer and possibly the increased organic compounds (Hutchinson, 1967) released by previous plankters facilitate these plankters growth and reproduction.

The fifth and smallest division Euglenophyta was represented by only one genera, *Trachelomonas* sp., at the Bigfork Bay station. This division undoubtedly has many more species in the shoreline areas where more organic matter is available for their use.

Ecological Relationships

In planktonic studies of algae certain species appear to be associated with one another. The name of the dominant species or sometimes the dominant and subdominant will be used as designations for the association. Hutchinson (1967) uses this form naming the dominant species and then the subdominant, e.g., *Fragilaria* - *Asterionella*; *Fragilaria* being the dominant and *Asterionella* the associated subdominant. One or more subdominants may be associated. This type of association is used in showing relationships between genera found during the study.

The genera showing dominance during the study were *Tabellaria quadrisepta* Knudson, *Fragilaria crotonensis* Kitton, *Rhizosolenia eriensis* H. L. Smith, *Dinobryon divergens*, *Stephanodiscus* sp., and *Asterionella formosa*. Each of these genera showed pulses during the study but none were strong enough to exhibit a bloom. The genera are listed in the order of seasonal pulses observed during the study.

Tabellaria quadrisepta occurred in its greatest numbers during June and early July. The largest population of this species, 186, 180 per liter, occurred at the Deep H_2O 30m level. Computer data indicates this species as being a cold water, high nutrient requiring species.

Fragilaria crotonensis was declining in total numbers at the beginning of the study and gave the impression of just completing a pulse. This species exhibited another pulse shortly after the fall turnover.

Dinobryon bavaricum and *D. sociale* showed preference for colder temperatures and higher nutrient levels than *D. divergens* or *D. sertularia*. Silicon dioxide levels are known to limit *D. divergens*.

Rhizosolenia eriensis, a diatom of the order Centrales, showed high population figures shortly after the ice breakup in the spring of 1969. Another pulse was detected during the summer when nutrients are more limited. Pearsall (1932) reported *R. eriensis* as requiring less nutrients than *Asterionella formosa*, *Fragilaria crotonensis* and *Tabellaria fenestrata*.

Asterionella formosa, a pennate form of the family Fragilariaceae, was found throughout the study. *Asterionella formosa* is considered to be a cold water form requiring high nutrient levels. This species during the summer is a subdominant associated with all the species described previously. Concentration of *A. formosa* fluctuated throughout the study with a general increase being noted from August on. The increase of *A. formosa* can be attributed to increase of dissolved nutrients two weeks prior to the pulse.

Synedra delicatissima W. Smith and *S. fasciculata* var. *fasciculata* (Ag.) Kutz. were found in numbers totaling 174,000 and 34,800 per liter respectively during and shortly after the spring thaw of 1969. The *Synedra* spp. showed a decline with the decreasing of silica, nitrate and sulfate in the summer months. *S. acus* var. *acus* Kutz. is limited mainly to the rivers and those stations more directly influenced by the rivers.

Other diatoms of the order Pennales that appeared commonly in the plankton samples were the genera *Amphora*, *Cymbella*, *Navicula* and

Pinnularia; other pennale genera were identified but occurred less frequently.

Cymbella and *Navicula* appeared in minor concentration throughout the study. Both genera, although usually free-floating, are often found attached to submerged objects, which accounts for limited numbers in plankton samples. Both genera were found in plankton samples at each station sporadically.

Cyclotella and *Melosira*, of the order Centrales, occurred at all stations and at the various depths sampled. *Melosira*, a diatom forming filamentous chain, is considered to be a cold water, high nutrient demanding diatom. *Melosira* occurred in limited numbers at all stations and depths. The nutrient level required, plus the physiological structure influenced by density, limits *Melosira* to periods of seasonal overturn. *Cyclotella* appeared in increased numbers during the late summer and fall periods similar to the distribution patterns of *Stephanodiscus*.

Ecological succession of dominant algal forms are the direct result of the chemical and physical requirements (see specific ecological requirements; analysis of covariance with multiple covariates).

Phytoplankton numeration was determined for each sampling period (exact dates are recorded in the Appendix, Interpretation of Numbers and Abbreviations). Phytoplankton in total number per liter was determined for each genera and where possbile the species were counted, e.g., *Dinobryon bavaricum*, *D. divergens*, *D. sertularia* and *D. sociale*.

Appendix II. Description, distribution and ecology of the Rotifer and Crustacean Plankton Communities, Flathead Lake, Montana: Tibbs and Potter (1972).

A preliminary list of the Flathead Lake zooplankton appears in Table 1. The table also presents the depth distribution of each species and temporal occurrence. Abundance is relative as compared to other species with consideration allowed for unusual temporal abundance of the more common forms.

The more common forms, *Daphnia spp.*, *Kellicottia longispina*, *Keratella cochlearis*, *Cyclops bicuspidatus thomasi*, and *Diaptomus ashlandi*, compose a community similar to that described by Scheffer and Robinson (1949) for Lake Washington. These forms occur commonly across the lake; the less common forms display more specific preferences for depth, temperature, and other factors associated with open lake or bay environments.

The three species of *Daphnia*, *D. thorata*, *D. longiremis*, and *D. rosea* (Fig. 1), are of particular interest due to temporal and spatial distributions that seem to be influenced primarily by temperature. Neither *Daphnia longiremis* nor *Daphnia rosea* have been reported from the lake though Bjork (1967, personal communication) incorrectly determined *D. longiremis* to be *D. longispina*. We have not yet determined whether these species have always been present or are recently introduced. Neither species has been observed in the few recovered samples from collections by Forbes and Elrod.

Daphnia longiremis is noted by Brooks (1957) to be a cold stenotherm. This species does maintain an association with cold waters of Flathead Lake and exhibits peak populations during late winter. At that season, *D. longiremis* is the most abundant cladoceran in the lake and occurs from the surface to depths of 50 meters. During summer and fall months when

Table 1. Preliminary Seasonal and Depth Distributions for Rotifera and Crustacea in Flathead Lake, Montana

Organism	Depths	Seasons
ROTIFERA		
Asplanchna sp.	surface	1,2,3*,4
Brachionus sp.?	surface	2
Chromogaster sp.	surface	2
Collotheca sp.	surface	2,3
Conochilus unicornis Rousselet	all depths	1*,2*,3,4
Dissotrocha sp.?	surface	2
Euchlanis sp.?	surface	1
Filinia longiseta (Ehrenberg)	mid, deep	1*,2,3,4*
Kellicottia longispina (Kellicott)	all depths	1*,2*,3*,4*
Keratella cochlearis (Gosse)	all depths	1*,2*,3*,4*
Keratella quadrata (Muller)	surface	1*,2,3,4
Ploesma sp.	surface	2
Polyarthra vulgaris Carlin	surface	1,2
Trichotria sp.	deep	1,4
Tylotrocha sp.?	surface	1
CLADOCERA		
Acroperus harpae Baird	surface	2
Bosmina longirostris (O.F. Muller)	surface	1*,2,3,4
Chydorus sphaericus (O.F. Muller)	surface	1,2,3,4
Daphnia longiremis Sars	all depths	1*,4
	deep	2,3
Daphnia rosea Sars	all depths	1,2,3,4
Daphnia thorata Forbes	surface	1,2*,3*,4
Eubosmina sp.	surface	1,2*,3,4
Eurycercus lamellatus (O.F. Muller)	surface	1,2,3,4
Leptodora kindtii (Focke)	deep, surface at night	2*,3
Scapholeberis kingi Sars	surface	1,2,3*,4
Sida crystallina O.F. Muller	mid	2
COPEPODA		
Cyclops bicuspidatus thomasi S.A. Forbes	all depths	1*,2*,3*,4*
Diaptomus ashlandi Marsh	surface, mid	1*,2*,3*,4*
Diaptomus leptopus S.A. Forbes	surface	2
Epischura nevadensis Lilljeborg	surface, mid	1,2,3
Eucyclops agilis (Koch)	surface	2
Ergasilus sp.	deep	1,4
Salmincola sp.	on fishes	1,2,3,4

1,spring; 2,summer; 3,autumn; 4,winter; *,abundant

surface - epilimnion
mid - metalimnion
deep - hypolimnion

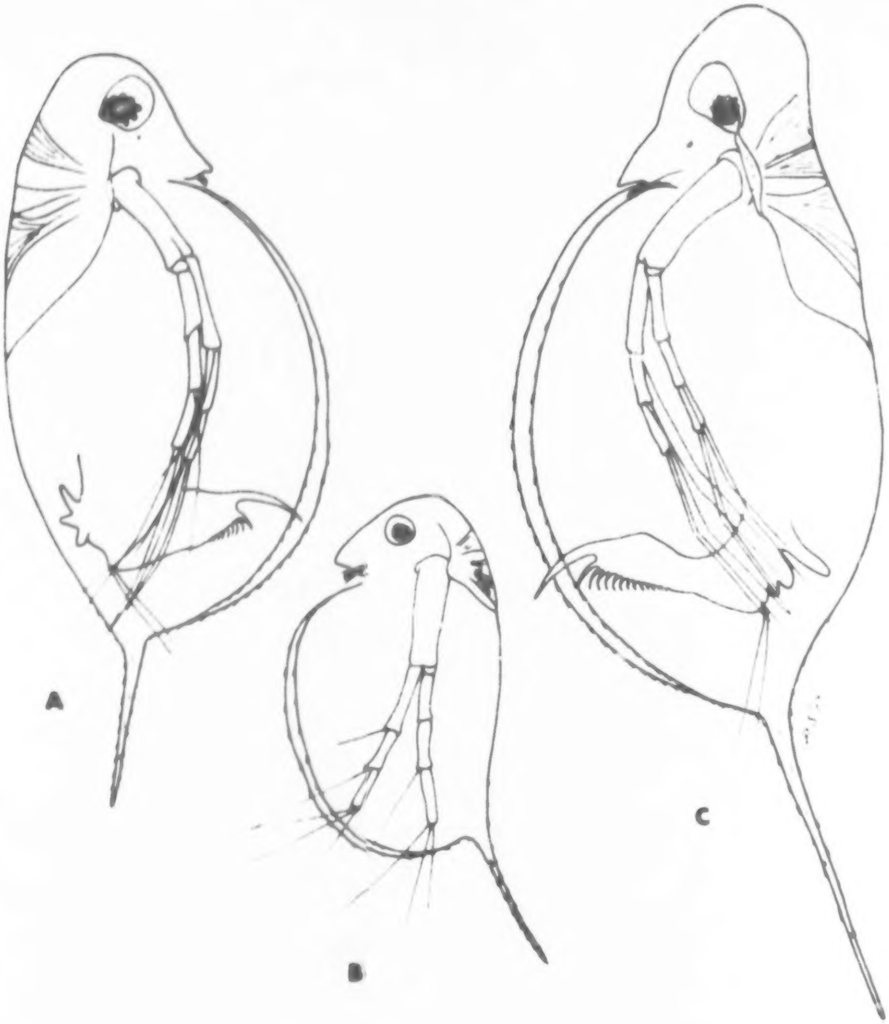

Figure 1. A. *Daphnia rosea*, mature female, Yellow Bay, 2 February, 1971; B. *Daphnia longiremis*, mature female, Yellow Bay, 30 January, 1971; C. *Daphnia thorata*, mature female, Woods Bay, 21 July, 1969.

the lake is stratified with warm surface temperatures *D. longiremis* restricts itself to hypolimnetic depths. At that time it is common, but it is not nearly as abundant as during winter months.

Daphnia rosea is the least abundant of the three species. It occurs at all depths at all seasons with modest populations developing in spring. *Daphnia rosea* has not previously been reported from the lake. It may have been present since early collection though not recognized as distinct from the other species. It may be a recent introduction from other Flathead Valley ponds where it is often abundant.

The most interesting temporal sequence is demonstrated by *Daphnia thorata*. Early exephippial females appear in the plankton as water temperatures reach five to seven degrees centigrade during April and May. These early individuals appear in shallow bays and near shore. The populations increase gradually through the summer. *Daphnia thorata* replaces *D. longiremis* in surface waters as summer stratification develops.

Highest densities occur in October and November when males appear in the population. Sexual reproduction with the formation of ephippia persists through early February, but populations begin to decline with cooling water temperatures of mid November. Between late February and April, *D. thorata* is absent from the Flathead Lake plankton community.

These three species are much used as food by pygmy whitefish (*Prosopium coulteri* (Eigenmann and Eigenmann)) and landlocked silver salmon or kokanee (*Oncorhynchus nerka* Waldbaum) (Hanzel, 1972). Possibly predation is an important influence on population size and particularly when females carry ephippia and are most visible.

Other species important in fish diets are *Leptodora kindtii* and *Epischura nevadensis*. Both are summer forms that display temporal periodicity similar to *Daphnia thorata*. The seasonal occurrence of *L. kindtii* in Flathead is supported by observations of Chambers, Burbidge, and Van Engel (1970) who noted the species to be present only at temperatures near and above ten degrees centigrade.

Leptodora displays distinct diel migrations. Individuals disperse between five and thirty meters depth during the day and congregate in the top ten meters of water during the night hours. Day distribution seems to be at depth with light below twenty foot candles, yet the few individuals that occur near the surface indicate that light may be only one influential factor.

Epischura is a form commonly eaten by planktivore fishes, yet it is much less common in the plankton than the cladocerans mentioned above. Importance as a food organism as compared to uncommon occurrence in the plankton probably reflects selectivity of fish predators (Brooks and Dodson, 1965).

Discussion

These few species displayed the most distinct periodicities and seemed to be controlled by environmental factors. The perennial species may be more tolerant of seasonal fluctuations or may display similar population variations that will become evident when quantitative analyses are completed.

Description of the modern plankton community and its comparison to earlier investigations has indicated a few changes of community structure that may have been influenced by accelerated eutrophication, fish introductions, and natural factors. We conclude that our efforts can profitably continue with a comparison between present conditions and previous collections and accounts. Analysis of sediment cores for plankton microfossils (Deevey, 1942) will be completed as another comparator.

A final goal will be the development of management suggestions based on previous history and the manner we expect that the lake may react to future fish introductions, pollution, and damming.

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Appendix III

SURVEY OF STREAM GAGING STATIONS

I. Flathead River at Flathead, British Columbia

Location: Lat. 49 deg.00'06", long. 114deg.28'30", on left bank 200 ft. north of international boundary and Flathead, British Columbia, 1.6 miles upstream from Sage Creek, 6.5 miles northwest of Trail Creek, Mont., and at mile 216.6.

Drainage Area: 450 sq. mi., approximately.

Period of Record: March 1929 to current year (no winter records prior to 1952). Prior to October 1934, published as "near Trail Creek, Mont."

Gage: Water-stage recorder. Datum of gage is 3,966.74 ft. above mean sea level. Prior to Sept.1, 1949, non-recording gage, and Sept. 1, 1949, to Oct. 4, 1964, water-stage recorder, at site 1,200 feet upstream at datum 9.22 ft. higher.

Average Discharge: 19 years (1951-70), 971 cfs (29.30 inches per year, 703,500 acre-ft. per year).

Extremes: Current year: Maximum discharge, 6,150 cfs May 26 (gage height, 7.30 ft); minimum daily, 105 cfs Feb. 13-15.
Period of record: Maximum discharge, 16,300 cfs June 8, 1964 (gage height, 8.00 ft, in gage well, 8.6 ft from outside floodmarks site and datum then in use), from rating curve extended above 8,000 cfs on basis of slope-area measurement of peak flow; minimum observed, 65 cfs Apr. 9, 1929, but may have been less during periods of no winter record.

Remarks: Records good except those for winter period, which are poor.

II. Flathead River near Columbia Fall

Location: Lat 48 deg. 21'43", long 114 deg. 11'02", in NW¼NW¼SE¼ sec.17, T.30N., R.20 W., Flathead County, on right bank 200 ft downstream from county road bridge at Columbia Falls, 5.7 miles downstream from South Fork, and at mile 143.0.

Drainage Area: 4,464 sq. mi.

Period of Record: May 1922 to Sept. 1923 (fragmentary), June 1928 to current year. Monthly discharge only for some periods, published in WSP 1316.

Gage: Water-stage recorder. Datum of gage is 2,977.67 ft above mean sea level (levels by Corps of Engineers). Prior to Nov. 12,1928, nonrecording gage at bridge 2oo ft upstream at datum 0.19 ft higher.

Average Discharge: 42 years, 9,652 cfs (29.36 inches per year, 6,993,000 acre-ft. per year), adjusted for change in contents in

Hungry Horse Reservoir since Oct. 1, 1951.

Extremes: Current year: Maximum discharge, 43,900 cfs June 5 (gage height, 12.34 ft); minimum daily, 1,010 cfs Jan. 7. Period of record: Maximum discharge, 176,000 cfs June 9, 1964 (gage height, 25.58 ft, from floodmarks), from rating curve extended above 95,000 cfs on basis of slope-area measurement of peak flow; minimum, 798 cfs Dec. 8, 1929 (gage height, -.08 ft). Flood in June 1894 reached a stage of 22.7 ft, from floodmarks (discharge, 142,000 cfs, from rating curve extended above 95,000 cfs on basis of slope-area measurement of peak flow in 1964).

Remarks: Records excellent. South Fork Flathead River, which contributes about one-third of flow, completely regulated by Hungry Horse Reservoir 11 miles upstream since Sept. 21, 1951.

III. Middle Fork Flathead River near Essex

Location: 1 mile downstream from Charlie Creek and 7½ miles southeast of Essex.
Gage: Water-stage recorder
Drainage Area: 408 square miles

Period of Record: April 1957 to September 1961 (no winter records after 1958).

Extremes: The maximum discharge during the period of record was 10,500 cfs (June 6, 1959) and the minimum daily determined, 85 cfs (January 1, 1958). The maximum discharge during the flood of June 8, 1964 was 57,900 cfs, from slope-area measurement of peak flow.

Remarks: There are no diversions above station.

IV. Skyland Creek near Essex

Location: 150 feet upstream from mouth and 10miles east of Essex.

Drainage Area: 8.09 square miles.

Period of Record: January 1946 to September 1952.

Gage: Water-stage recorder

Average Discharge: 6 years (1946-52), 19.2 cfs or 13,900 acre-feet per year.

Extremes: Annual maximums for water years 1954, 1959 to date (1965). The maximum discharge during the period of continuous record was 284 cfs (May 22, 1948)and the minimum, 0.1 cfs (November 15, 1946).

The maximum discharge during the flood of June 8, 1964 was 3,580 cfs, from slope-area measurement of peak flow. The highest annual runoff was 18,140 acre-feet (1950) and the lowest, 9,440 acre-feet (1949).

Remarks: There are no diversions above station.

V. Bear Creek near Essex

Location: 1 mile downstream from Autumn Creek and 8½ miles east of Essex.

Drainage Area: 20.7 square miles.

Period of Record: January 1946 to September 1952

Gage: Water-stage recorder

Average Discharge: 6 years (1946-52) , 46.0 cfs or 33,300 acre-feet per year.

Extremes: Maximum discharge during the period of record was 696 cfs (May 22, 1948) and the minimum daily, 5.5 cfs (January 21 to March 4, March 8-16, 1949). The maximum discharge during the flood of June 8,1964 was 8,380 cfs, from slope-area measurement of peak flow. The highest annual runoff was 41,500 acre-feet (1951) and the lowest, 22,170 acre-feet (1949).

Remarks: There are a few small diversions above station.

VI. Middle Fork Flathead River at Essex

Location: At the highway bridge 0.6 miles upstream from Ole Creek, 0.7 miles southeast of Essex, and 4 miles downstream from Bear Creek.

Drainage Area: 510 square miles.

Period of Record: October 1939 to September 1953, June 1956 to September 1964.

Gage: Water-stage recorder.

Average Discharge: 21 years, 922 cfs or 766,700 acre-feet per year.

Extremes: Maximum discharge was 75,300 cfs (June 8, 1964), from slope-area measurement of peak flow, and the minimum daily, 30 cfs (January 22, 1940).
Highest annual runoff was 1,142,000 acre-ft. (1959), and the lowest 336,400 acre-feet (1941).

Remarks: There are no significant diversions above the station.

VII. Middle Fork Flathead River at West Glacier (Belton)

Location: West Glacier (Belton), ½ mile upstream from highway bridge, and two miles upstream from outlet of Lake McDonald.

Drainage Area: 943 sq. miles

Period of Record: October 1911 to September 1923 (no winter records some years), March 1929 to September 1933, August 1943 to November 1947.

Gage: Staff gage

Average Discharge: 13 years (1910-12, 1915-16, 1918-19, 1920-21, 1929-33, 1943-47) ; 2,294 cfs or 1,661,000 acre-feet per year

Extremes: Maximum discharge during the period of record was 45,000 cfs (June 21, 1916) and the minimum observed, 115 cfs (March 1,1929). The **highest** annual runoff was 2,450,000 acre-feet (1916) and the lowest 914, 800 acre-feet (1944).

Remarks: There are no significant diversions above the station.

VIII. Lake McDonald Outlet at Lake McDonald

Location: On the highway bridge at lower end of Lake McDonald, in Glacier National Park.

Drainage Area: 175 square miles.

Period of Record: Records are available for some summer months during the period 1912-1914.

Gage: staff gage

Extremes: Maximum and minimum discharges were not determined.

Remarks: No diversions above station.

IX. Middle Fork Flathead River near West Glacier (Belton)

Location: Lat. 48 deg. 29'43", long. 114 deg. 00' 33", in S½SW¼NE¼ sec. 34, T.32N., R.19 W., Flathead County, on left bank 0.8 mile downstream from McDonald Creek, 1.3 miles west of West Glacier (formerly Belton), and 3.8 miles upstream from mouth.

Drainage Area: 1,128 sq mi.

Period of Record: Oct. 1939 to current year. Prior to October 1947, published as "near Belton."

Gage: Water-stage recorder. Altitude of gage is 3,130 ft (from river-profile map). Prior to Nov. 22, 1950, nonrecording gage at present site and datum.

Average Discharge: 31 years, 2,916 cfs (35.11 inches per year, 2,113,000 acre-ft. per year).

Extremes: Current year: Maximum discharge, 23,400 cfs June 5 (gage height, 9.34 ft); minimum, 244 cfs Jan. 8 (gage height, 0.84 ft).
Period of record: Maximum discharge, about 140,000 cfs June 9, 1964 (gage height, 36.36 ft, from flood-marks), from rating curve extended above 35,000 cfs on basis of flood volume-hydrographic comparison; minimum, less than 173 cfs Nov. 27, 1952 (stage below intake pipe).

Remarks: Records excellent.

X. South Fork Flathead River at Spotted Bear Ranger Station, near Hungry Horse:

Location: Lat 47 deg. 55'20", long 113 deg. 31'25", in SE¼SW¼ sec. 17, T.25 N., R. 15 W ., on left bank 600 ft south of Spotted Bear ranger station, 1,000 ft upstream from Spotted Bear River, 40 miles southeast of Hungry Horse, and at mile52.9

Drainage Area: 958 sq. mi.

Period of Record: August 1948 to September 1957, August 1959 to September 1967 (discontinued).

Gage: Water-stage recorder. Altitude of gage is 3,670 ft (from river-profile map).

Average discharge: 17 years, 1,935 cfs (1,401,000 acre-ft per year).

Extremes: Maximum discharge during year, 18,500 cfs May 23, (gage height, 12.09 ft); minimum daily, 240 cfs Jan. 24.
1948-57, 1959-67: Maximum discharge, 36,700 cfs June 8, 1964 (gage height, 18.96 ft in gage well, 19.5 ft from outside flood-marks), from rating curve extended above 18,000 cfs on basis of slope-area measurement of peak flow; minimum, less than 121 cfs Dec. 26, 1952 (stage below intake pipes).

Remarks: Records excellent except those for period of no gage-height record, which are good. No regulation or diversion above station.

XI. Spotted Bear River near Hungry Horse

Location: 1/3 mile upstream from mouth and 40 miles southeast of Hungry Horse.

Drainage Area: 184 square miles

Period of Record: October 1948 to September 1956.

Gage: Water-stage recorder

Average Discharge: 8 years, 380 cfs or 275,100 acre- feet per year.

Extremes: The maximum discharge during the period of record was 5,480 cfs, (May 20, 1954) and the minimum, 20 cfs (January 5, 1953), but may have been less during periods of ice effect. The maximum discharge during the flood of June 8. 1964 was 20,200 cfs, from slope-area measurement of peak flow. The highest annual runoff was 324,100 acre-feet (1954) and the lowest 208,700 acre-feet (1949).

Remarks: There are no diversions above the station.

XII. South Fork Flathead River above Twin Creek, near Hungry Horse

Location: Lat 47 deg. 58'45", long 113 deg. 33'36", in NE¼NW¼NE¼ sec. 36, T.26 N., R. 16 W., Flathead County, Flathead National Forest, on left bank 0.1 mile downstream from Tin Creek, 0.4 mile upstream from Twin Creek, 36.3 miles southeast of Hungry Horse, and at mile 46.7

Drainage Area: 1,160 sq. mi.

Period of Record: October 1964 to current year.

Gage: Water-stage recorder. Altitude of gage is 3,575 ft (from river-profile map).

Extremes: Current year: Maximum discharge, 23,800 cfs June 6 (gage height, 14.02 ft); minimum daily, 180 cfs Jan. 7. Period of record: Maximum discharge, 23,800 cfs June 6, 1970 (gage height, 14.02 ft.); minimum daily, 180 cfs Jan. 7, 1970.
Flood of June 8, 1964, reached a stage of 20.87 ft, from high- water profile (discharge, 50, 900 cfs, by slope-area measurement of peak flow).

Average Discharge: 6 years, 2,344 cfs (27.45 inches per year, 1,698,000 acre ft per year).

Remarks: Records excellent except those for winter period, which are poor.

XIII. Twin Creek near Hungry Horse

Location: Lat 47 deg. 59'10", long 113 deg. 33'30", in E½ sec. 25, T.26 N., R.16 W , on left bank 300 ft. upstream from road bridge, 0.1 mile upstream from mouth, and 36 miles southeast of Hungry Horse.

Drainage area: 47.0 sq. mi.

Period of Record: August 1948 to September 1956, October 1964 to September 1967 (discontinued).

Gage: Water-stage recorder with thermograph attachment. Altitude of gage is 3,610 ft (from river-profile map).

Average Discharge: 11 years, 121 cfs (87,600 acre-ft. per year).

Extremes: Maximum discharge during year, 1,950 cfs May 22 (gage height, 7.77 ft); minimum, 9.9 cfs Oct. 1, but may have been less during period of ice effect.
1948-56, 1964-67: Maximum discharge, 2,790 cfs May 22 (gage height, 8.33 ft), from rating curve extended above 1,000 cfs on basis of slope-area measurement at gage height 8.1 ft; minimum, 3.9 cfs Mar.8, 1952, Nov. 26, 1952 (gage height, 1.77 ft), but may have been less during periods of ice effect.
Flood of June 8,1964, reached a stage of 12.34 ft. from high water mark in well, 13.1 ft from high water profile, backwater from channel obstructions (discharge, 5,830 cfs by slope-area measurement of peak flow).

Remarks: Records fair. No regulation or diversion above station.

XIV. Lower Twin Creek near Hungry Horse

Location: ½ mile upstream from mouth and 35 miles southeast of Hungry Horse.

Drainage Area: 22.4 sq. mi.

Period of Record: August 1948 to September 1956.

Gage: Water-stage recorder

Average Discharge: 8 years, 69.4 cfs or 50,240 acre-feet per year.

Extremes: Maximum discharge during period of record, 909 cfs (May 21, 1956) and the minimum, 0.8 cfs (January 28, 1952).
Maximum discharge during the flood of June 8, 1964 was 5,110 cfs, from slope-area measurement of peak flow.
The highest annual runoff was 58,810 acre-feet (1950) and the lowest 40,890 (1949).

Remarks: There are no diversions above the station.

XV. Soldier Creek near Hungry Horse

Location: Lat. 47 deg. 59'30", long. 113 deg. 34'50", in NE¼NE¼ sec.26, T.26 N., R.16 W., on left bank 200 ft upstream from culverts on west shore road, 0.2 mile upstream from mouth, and 35 miles southeast of Hungry Horse.

Drainage Area: 4.77 sq mi.

Period of Record: October 1964 to April 1967 (discontinued).

Gage: Water-stage recorder with thermograph attachment. Altitude of gage is 3,640 ft (from river-profile map).

Extremes: Maximum discharge during period of October to April, 24 cfs Apr. 12 (gage height, 3.02 ft); maximum gage height, 3.04 ft Jan. 25 (backwater from ice); minimum, 2.1 cfs Nov. 8 (gage height, 2.30 ft), but may have been less during period of ice effect.
1964-67: Maximum discharge, 128 cfs Dec. 23, 1964 (gage height, 4.20 ft); minimum, that of Nov. 8, 1966.
Flood of June 8, 1964, reached a stage of 5.7 ft, from high water profile (discharge, 206 cfs, by flow-through-culvert measurement).

Remarks: Records good. No regulation or diversion above station.

XVI. Sullivan Creek near Hungry Horse

Location: Lat 48 deg. 01'45", long 113 deg. 42'12", in NW¼SW¼ sec.12, T.26 N., R.17 W., Flathead County, Flathead National Forest, on left bank 0.3 mile downstream from Quintonkon Creek, 1.7 miles upstream from Hungry Horse Reservoir flow line, and 29.5 miles southeast of Hungry Horse.

Drainage Area: 71.3 sq mi.

Period of Record: September 1948 to September 1956, August 1959 to current year.

Gage: Water-stage recorder. Altitude of gage is 3,630 ft. (from topographic map).

Average Discharge: 19 years, 220 cfs (41.91 inches per year, 159,400 acre-ft per year).

Extremes: Current year: Maximum discharge, 2,770 cfs June 16 (gage height, 5.65 ft); minimum daily, 25 cfs Jan. 7. Period of record: Maximum discharge, 5,020 cfs June 8, 1964 (gage height, 7.21 ft in gage well, 8.3 ft from outside floodmarks), from rating curve extended above 1,800 cfs on basis of slope-area measurement of peak flow; minimum daily, 10 cfs Nov. 26, 1952

Remarks: Records good except those for winter period, which are poor.

XVII. Graves Creek near Hungry Horse

Location: Lat 48 deg. 07'50", long 113 deg. 48'35", in SE¼ sec. 1, T.27 N., R.18 W., on left bank 500 ft upstream from Hungry Horse Reservoir flow line and 22 miles southeast of Hungry Horse.

Drainage area: 27.0 sq mi.

Period of Record: August 1948 to September 1956, October 1964 to September 1967 (discontinued).

Gage: Water-stage recorder with thermograph attachment. Altitude of gage is 3,600 ft (from topographic map). Prior to Oct. 1, 1951, at site 2½ miles downstream at different datum.

Average discharge: 11 years, 135 cfs (97,740 acre-ft per year).

Extremes: Maximum discharge during year, 1,190 cfs May 22 (gage height, 4.75 ft); minimum, 7.9 cfs Sept. 29 (gage height, 1.97 ft).
1948-56, 1964-67: Maximum discharge, 3,780 cfs June 18, 1965 (gage height, 6.27 ft), from rating curve extended above 1,300 cfs on basis of slope-area measurement at gage height 5.83 ft; minimum daily, 4.5 cfs Nov. 26, 1952

Remarks: Records good. No regulation or diversion above station.

XVIII. Canyon Creek near Hungry Horse

Location: Lat 48 deg. 12'50", long 113 deg. 45'40", in NW¼SE¼SW¼ sec.4, T.28 N., R.17 W., on right bank 50 ft downstream from bridge on east shore road, 400 ft upstream from Hungry Horse Reservoir flow line, and 18 miles southeast of Hungry Horse.

Drainage area: 5.8 sq mi, approximately.

Period of Record: October 1964 to April 1967 (discontinued).

Gage: Water-stage recorder with thermograph attachment. Altitude of gage is 3,580 ft (from river-profile map).

Extremes: Maximum discharge during period October to April, 13 cfs Apr. 11 (gage height, 2.33 ft); minimum, 1.2 cfs Mar. 15-17 (gage height, 1.76 ft).
1964-67: Maximum discharge, 140 cfs June 4, 1965 (gage height, 3.25 ft); minimum, 1.2 cfs Mar. 4, 1966, Mar. 15-17, 1967.

Remarks: Records good. No regulation or diversion above station.

XIV. Wounded Buck Creek near Hungry Horse

Location: Lat. 48 deg.16'40", long 113 deg. 56'10", in SW¼SW¼NW¼ sec.17, T.29 N., R.18 W., on right bank 10 feet upstream from culvert on west shore road, 800 ft upstream from Hungry Horse Reservoir flow line, and 9 miles southeast of Hungry Horse.

Drainage area: 13.6 sq mi.

Period of Record: October 1964 to April 1967 (discontinued).

Gage: Water-stage recorder with pressure recording bubbler system. Altitude of gage is 3,580 ft (from topographic map).

Extremes: Maximum discharge during period October to April, 150 cfs Jan. 28 (gage height, 3.80 ft); minimum, 13 cfs Mar. 7, 14 (gage height, 1.17 ft)
1964-67: Maximum discharge, 970 cfs June 18, 1965 (gage height, 14.13 ft), from rating curve extended above 240 cfs on basis of flow-through-culvert measurements at gage heights 10.8 and 14.13 ft.; minimum, that of Mar. 7, 14, 1967, but may have been less during period of ice effect in 1966.

Remarks: Records good. No regulation or diversion above station.

XV. Emery Creek near Hungry Horse

Location: Lat. 48 deg. 21'30", long. 113 deg. 55'35", in SE¼NE¼SW¼ sec. 17, T.30 N, R.18 W., on left bank 1,000 ft upstream from bridge on east shore road, 900 ft upstream from Hungry Horse Reservoir flow line, and 6 miles southeast of Hungry Horse.

Drainage Area: 26.4 sq mi.

Period of Record: October 1964 to April 1967 (discontinued).

Gage: Water-stage recorder with thermograph attachment. Altitude of gage is 3,590 ft (from topographic map)

Extremes: Maximum discharge during period October to April, 37 cfs Apr. 25 (gage height, 1.70 ft); maximum gage height, 2.43 ft Jan. 25 (backwater from ice); minimum daily discharge, 4.5 cfs Nov. 11.
1964-67: Maximum discharge, 371 cfs Apr. 29, 1965 (gage height, 2.89 ft); maximum gage height, 3.90 ft. Dec. 19, 1964 (backwater from ice); minimum daily, 3.0 cfs Feb. 15, 1966.
Flood of June 8, 1964, reached a stage of 3.39 ft, from high-water profile (discharge, 832 cfs by slope-area measurement of peak flow).

Remarks: Records good. No regulation or diversion above station.

XVI. South Fork Flathead River near Columbia Falls

Location: Lat. 48 deg. 21'24", long. 114 deg. 02'12", in SW¼SE¼SW¼ sec. 16, T.30 N., R.19 W1, Flathead County, on right bank 1.7 miles downstream from Hungry Horse Dam, 3.5 miles upstream from mouth, and 6.8 miles east of Columbia Falls.

Drainage Area:
1,663 sq mi.

Period of Record: September 1910 to January 1911 (discharge measurements only), February 1911 to September 1913 (no winter records), October 1913 to August 1916 (scattered daily discharge only), water years 1917-22 (annual maximum), April 1923 to November 1924 (no winter records), July to October 1925, May to November 1927, May 1928 to current year. Monthly discharge only for some periods, published in WSP 1316.

Gage: Water-stage recorder. Datum of gage is 3,040.0 ft above mean sea level (levels by Bureau of Reclamation). September 1910 to September 1916, nonrecording gage, and April 23,1923, to Sept. 30, 1928, water-stage recorder at site 3 miles downstream at different datum. Oct. 1, 1928, to Sept. 30,1952, water-stage recorder at site 1.5 miles downstream at different datum.

Average Discharge: 42 years, 3,523 cfs (28.77 inches per year, 2,552,000 acre-ft per year), adjusted for change in contents in Hungry Horse Reservoir since Oct. 1, 1951.

Extremes: Current year: Maximum discharge, 11,300 cfs Apr. 25 (gage height, 10.76 ft); minimum daily, 163 cfs

June 29, July 1, 14. Period of record: Maximum discharge observed, 46,200 cfs June 19, 1916 (gage height, 16.6 ft, site and datum then in use), from rating curve extended above 20,000 cfs; minimum observed, 7.3 cfs Sept. 24, 1951 (gage height, 0.52 ft, dam closure), site and datum then in use; minimum daily, 7.3 cfs Sept. 24, 1951.

Remarks: Records excellent. Flow regulated since Sept. 21, 1951, by Hungry Horse Reservoir

XVII. Flathead River at Columbia Falls

Location: Lat 48 deg. 21'43", long. 114 deg. 11'02", in NW¼NW¼SE¼ sec. 17, T. 30 N., R.20 W., Flathead County, on right bank 200 ft downstream from county road bridge at Columbia Falls, 5.7 miles downstream from South Fork, and at mile 143.0

Drainage Area: 4,464 sq mi.

Period of Record: May 1922 to September 1923 (fragmentary), June 1928 to current year. Monthly discharge only for some periods, published in WSP 1316.

Gage: Water-stage recorder. Datum of gage is 2,977.67 ft above mean sea level (levels by Corps of Engineers). Prior to Nov. 12, 1928, nonrecording gage on bridge 200 ft upstream at datum 0.19 ft higher.

Average Discharge: 42 years, 9,652 cfs (29.36 inches per year, 6,993,000 acre-ft per year), adjusted for change in contents in Hungry Horse Reservoir since Oct. 1, 1951.

Extremes: Current year: Maximum discharge, 43,900 cfs June 5 (gage height, 12.34 ft); minimum daily, 1,010 cfs Jan. 7. Period of record: Maximum discharge, 176,000 cfs June 9, 1964 (gage height, 25,58 ft, from flood marks), from rating curve extended above 95,000 cfs on basis of slope-area measurement of peak flow; minimum, 798 cfs Dec. 8, 1929 (gage height, -0.08 ft). Flood in June 1894 reached a stage of 22.7 ft, from floodmarks (discharge, 142,000 cfs, from rating curve extended above 95,000 cfs on basis of slope-area measurement of peak flow in 1964).

Remarks: Records excellent. South Fork Flathead River, which contributes about one-third of flow, completely regulated by Hungry Horse Reservoir 11 miles upstream since Sept. 21, 1951

XVIII. Flathead River near Kalispell

Location: at highway bridge, 3 miles east of Kalispell.

Period of Record: May 1928 to September 1945 (gage heights only).

Gage: chain gage, datum of gage is at mean sea level (Somers datum).

Extremes: Maximum elevation 2,913.95 ft (May 27, 1928) and the minimum elevation, 2,899.25 ft (December 17, 1940)

XIX. Logan Creek at Tally Lake near Whitefish

Location: 2½ miles downstream from Tally Lake and 10 miles west of Whitefish.

Drainage Area: 183 sq mi.

Period of Record: August 1931 to August 1934 (fragmentary), May 1936 to September 1942, May 1945 to September 1947

Gage: staff gage

Average Discharge: 8 years (1936-42, 1945-47), 75.0 cfs or 54,300 acre-ft per year.

Extremes: Maximum discharge, 1,380 cfs (May 11, 1947), minimum, 0.7 cfs (September 1, 2, 1940). Highest annual runoff was 125,600 acre-feet (1947), lowest, 15,920 acre-feet (1941).

Remarks: There is natural storage in Tally Lake.

XX. Logan Creek near Whitefish

Location: 100 feet upstream from Good Creek and 10 miles northwest of Whitefish.

Drainage Area: 199 sq mi.

Period of Record: April to September 1931.

Gage: staff gage

Extremes: Maximum discharge, 240 cfs (May 8), minimum, 1.2 cfs (September 4, 5)

Remarks: There is natural storage in Tally Lake.

XXI. Stillwater River near Whitefish

Location: 600 ft downstream from highway bridge, 7 mi. southwest of Whitefish, 10 miles upstream from Whitefish River.

Drainage Area: 524 sq mi.

Period of Record: October 1930 to September 1950.

Gage: water-stage recorder

Average Discharge: 20 years, (1930-50), 340 cfs or 246,100 acre-ft per year.

Extremes: Maximum discharge: 4,330 cfs (May 26, 1948) and the minimum daily, 40 cfs (December 24, 1944). The highest annual runoff was 405,400 acre-feet (1948) and the lowest 90,200 acre-feet (1944).

Remarks: There are a few diversions for irrigation above the station.

XXII. Stillwater River near Kalispell

Location: On highway bridge 5 miles upstream from Whitefish River and 5 miles north of Kalispell.

Drainage Area: 537 sq mi.

Period of Record: October to December 1906, January to May 1907 (gage heights only), May to August 1922, July 1928 to October 1930 (fragmentary).

Gage: staff gage

Extremes: Maximum discharge, 2,750 cfs,(May 22, 1922), minimum, 26 cfs (November 11, 1929).

Remarks: There were no diversions above the station.

XXIII. Whitefish River near Kalispell

Location: 8 miles upstream from mouth and 8 miles north of Kalispell.

Drainage Area: 170 sq mi.

Period of Record: August to November 1928, April 1929 to Sept. 1950.

Gage: Water- stage recorder

Average Discharge: 21 years (1929-50), 191 cfs or 138,300 acre-ft per year.

Extremes: Maximum discharge, 1,290 cfs (May 30, 1948), minimum, 4.5 cfs (October 18, 1934). Highest annual runoff, 202,400 acre-ft

(1934) and the lowest, 73,990 acre-ft (1944).

Remarks: There were diversions for Whitefish municipal water supply and for irrigation of about 120 acres above the station. Some regulation by Whitefish Lake.

XIV. Flathead River at Demersville

Location: At Demersville, 3 mi south of Kalispell.

Period of Record: April 1909 to July 1912, April 1928 to September 1945 (gage heights only)

Gage: wire-weight gage. Datum of gage is at mean sea level (Somers datum).

Extremes: Maximum elevation, 2,904.94 ft (June 17, 1933), minimum, 2,881.86 ft (Dec. 18-26, 1936)

XV. Ashley Creek near Kila

Location: upstream end or right abutment of bridge, about 1½ mi downstream from Ashley Lake, and 7 mi northwest of Kila.

Drainage Area: 44.2 sq mi.

Period of Record: Aug to Nov. 1916.

Extremes: Maximum discharge, 20cfs (Aug 9), minimum, 4.2 cfs (Sept 29).

Remarks: No diversions above station. Floodwater stored in Ashley Lake for release during irrigation season.

Gage: staff gage

XVI. Ashley Creek near Kalispell

Location: 2½ mi downstream from Smith Lake, 5 mi west of Kalispell.

Drainage Area: 201 sq mi.

Period of Record: May 1931 to Feb 1933, June 1934 to Sept. 1950.

Gage: wire-weight gage

Average Discharge: 17 years (1931-32, 1934-50), 30.4 cfs or 22,010 acre-ft per year.

Extremes: Maximum discharge, 749 cfs (May 27, 1948), minimum, no flow at times. Highest annual runoff, 78,940 acre-ft (1948), lowest, 1,080 acre-ft (1941).

Remarks: There are diversions for irrigation of about 100 acres above the station. Floodwater stored in Ashley Lake for release during irrigation season.

XVII. Flathead River at Damon Ranch near Kalispell

Location: At Damon Ranch, 7 mi southeast of Kalispell.

Period of Record: April 1909 to July 1912, May 1928 to Sept. 1945, (gage heights only).

Gage: wire-weight gage. Datum of gage is at mean sea level (Somers datum).

Extremes: Maximum elevation, 2,900.94 ft (June 17, 1933), minimum, 2,881.55 ft (Jan 27-31, 1937

XVIII. Flathead River at Therriault Ferry near Kalispell

Location. at Therriault Ferry, 9 mi southeast of Kalispell.

Period of Record: Oct 1934 to Sept 1945 (gage heights only)

Gage:staff gage. Datum of gage is at mean sea level (Somers datum).

Extremes: Maximum elevation, 2,894.23 ft (May 16, 1936), minimum, 2,881.28 ft (Jan 21-23, 1937).

XIX. Flathead River near Holt

Location: At Keller Ranch, 0.7 mi upstream from Holt.

Period of Record: April 1909 to July 1912, June 1928 to Sept 1938, Oct. 1939 to Sept. 1945 (gage heights only)

Gage: staff gage. Datum of gage is at mean sea level (Somers datum).

Extremes: Maximum elevation, 2,897.35 ft (May 29-30, 1928), from floodmark, and the minimum, 2,881.24 ft (Jan 25-28, 1930).

XX. Little Bitterroot River near Marion

Location: at log bridge 70 ft downstream from outlet of Little Bitterroot Lake and 2 mi southwest of Marion.

Drainage Area: 31.8 sq mi.

Period of Record: Jan 1910 to Sept 1916 (no winter records 1911-14).

Gage: staff-gage

Extremes: Maximum discharge, 53 cfs (Ap 27, 1916), minimum, no flow (Jan 19-23, 1915).

Remarks: There was natural storage in Little Bitterroot Lake with some regulation by temporary dams at lake outlet.

RESERVOIRS

XXII. Hungry Horse Reservoir near Hungry Horse

Location: In block 14 of Hungry Horse Dam, 3 miles southeast of Hungry Horse.

Drainage Area: 1,654 sq. mi.

Period of Record: September 1951 to date (1965).

Gage: water-stage recorder

Extremes: Maximum contents, 3,461,000 acre-ft (July 3-4, 1955, August 6, 1956) and the minimum contents observed since normal low operating level reached in May 1952, 607,700 acre-ft, (January 13, 1953).

Remarks: Storage began September 21, 1951. The usable capacity is 3,428,000 acre-ft. Water is used for power, flood control, irrigation and recreation.

XXIII. Flathead Lake near Holt

Location: 2 miles east of the mouth of the Flathead River near Holt.

Period of Record: April 24 to August 4, 1900.

Gage: Staff gage.

Datum of gage is unknown.

Extremes: The maximum elevation was 12.60 ft (May 17), minimum, 4.00 ft (Aug. 4-5).

XXIV. Flathead Lake at Somers

Location: At the steamboat dock at Somers.

Drainage Area: 7,086 sq mi.

Period of Record: January 1910 to date (1965). Published as "at Polson" prior to April 1923. Staff-gage readings were reported prior to 1924. Some supplemental readings were obtained in 1900, 1908 and 1909. The Polson readings were obtained at the south end of the lake at Polson in Lake County.

Gage: water-stage recorder

Extremes: The maximum contents was 2,208,000 acre-feet (June 19, 1933) and the minimum 347,000 acre-feet (Dec. 5, 1936). The lake was nearly 4 ft higher during the flood of June 1894.

Remarks: Natural storage was increased by construction of Kerr Dam 4 miles downstream from natural lake outlet. Storage began April 11, 1938. The usable capacity is 1,791,000 acre-ft. Water is used for power, flood control, irrigation and recreation.

STREAM GAGING STATIONS

XXV. Swan River near Bigfork

Location: At outlet of Swan Lake, 1,000 ft downstream from Johnson Creek, and 5 miles southeast of Bigfork.

Drainage Area: 671 sq. mi.

Period of Record: May 1922 to date (1963) and gage heights only from October 1910 to May 1911.

Gage: water-stage recorder

Average Discharge: 39 years (1922-61), 1,127 cfs or 815,900 acre- ft per year.

Extremes: Maximum discharge, 8,400 cfs (May 24, 1948), minimum, 193 cfs (January 26-29, 1930). Highest annual runoff, 1,350,000 acre-ft (1928), lowest, 439,300 acre-ft (1941).

Remarks: There are diversions for irrigation of about 360 acres above the station.

XXVI. Hell Roaring Creek (Big Creek) near Polson

Location: Just downstream from the power plant, 3/4 mi. upstream from mouth, and 7 miles east of Polson.

Drainage Area: 6.41 sq mi.

Period of Record: June 1917 through September 1932. 1960 to date.

Gage: water-stage recorder, crest-stage records(from 1960 to date.)

Average Discharge: 15 yrs. (1917-32), 6.64 cfs or 4,807 acre-ft per year.

Extremes: Maximum discharge, 104 cfs (June 9, 1917), minimum, no flow at times during November and December, 1932, when power plant was shut down. Highest annual runoff, 7,420 acre-ft (1928), lowest 3,180 acre-ft (1920).

Remarks: Records include water diverted by the Flathead irrigation project canal for irrigation of lands downstream and the Polson municipal water-supply pipeline. The flow is regulated by the power plant and two reservoirs with a combined capacity of about 200 acre-ft.

XXVII. Flathead River Near Polson

Location: ½ mi downstream from Kerr Dam, 4 mi. west of Polson, 5 mi downstream from Flathead Lake.

Drainage Area: 7,096 sq mi.

Period of Record: July 1907 to date (1963).

Gage: water-stage recorder

Average Discharge: 54 years (1907-1961), 11,610 cfs or 8,405,000 acre-ft per year, adjusted since October 1, 1952 for change in contents in Hungry Horse Reservoir and Flathead Lake.

Extremes: Maximum discharge, 82,800 cfs (May 29, 1928), minimum, probably less than 5 cfs (April 13, 1938), and the minimum daily, 32 cfs (April 12, 1938). Flood of June 1894 was about 110,000 cfs, from lake elevation-discharge study. Highest annual runoff, 12,500,000 acre-ft (1927), lowest, 3,762,000 acre-ft (1941) not adjusted for Flathead Lake regulation.

Remarks: There are diversions above the station for irrigation of about 10,000 acres . Flathead Projects pumps can divert up to 12,000 acre-ft per month when required for irrigation of lands downstream from station. Flow has been regulated by Flathead Lake (Kerr Dam) since April 1938 and Hungry Horse Reservoir since September 1951.

USGS STREAMFLOW STATIONS CURRENTLY
IN OPERATION IN UPPER FLATHEAD BASIN
WATER YEAR 1972

Flathead River Basin

12355000	Flathead River at Flathead B. C.
12355500	Flathead River near Columbia Falls
12358500	M. Fk. Flathead River near West Glacier
12359800	So. Fk. Flathead River above Twin
12361000	Sullivan Creek near Hungry Horse
12361950	Hungry Horse Creek near Hungry Horse
12362000	Hungry Horse Reservoir
12362500	So. Fk. Flathead River near Columbia Falls
12363000	Flathead River at Columbia Falls
12370000	Swan River near Bigfork
12371500	Flathead Lake at Somers
12371550	Flathead Lake at Polson
12372000	Flathead River near Polson

Miscellaneous Measurements

Bowman Creek
McDonald Creek
Quartz Creek

Crest-Stage Gages

57-1	Skyland Creek near Essex
57-2	Moccasin Creek near West Glacier
57-3	M. Fk. Flathead River Trib. @ West Glacier

Appendix IV

Chemical analyses of water from selected wells and springs, Kalispell Valley, Mont.
(Analyses made by Montana State Board of Health. Analytical results in milligrams per liter)

Location	Date of Collection	Aquifer	Temperature (deg. F)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium Potassium (Na+K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids	Total Hardness ($CaCO_3$)
B27-20-3ab	11/3/64	Deep artesian	49	0	31	15	1	159	0	6	2	0	0	146	138
B27-20-8aa	9/29/65	Flood-plain sand	--	1.36	118	112	255	700	0	200	250	.6	208	1,430	755
B27-20-20ab	9/22/64	Flood-plain sand	--	14.12	108	20	20	406	0	15	31	0	.9	402	352
B27-20-26ab	9/29/65	Precambrian bedrock	--	.96	36	34	14	300	0	6	5	.2	.9	234	230
B27-21-12ab	9/22/64	Deep artesian	53	0	47	26	14	290	0	5	7	.1	0	220	224
B27-21-12dc	11/4/64	Flood-plain sand	48	4.00	88	31	21	421	0	8	21	0	5.0	382	347
B28-20-3bb	11/3/64	Deep artesian	--	.20	43	18	6	223	0	7	2	0	0	182	180
B28-20-15cb3	11/3/64	Deep artesian	48	.54	26	24	9	204	0	11	3	0	0	162	163
B28-20-18bd2	11/4/64	Deep artesian	49	0	39	21	0	204	0	5	3	0	0	160	[illegible]
B28-20-20dc	9/22/64	Deep artesian	51	.54	45	13	9	214	0	3	5	.1	0	166	[illegible]
B28-20-22aa	9/22/64	Shallow artesian	50	.14	53	17	0	232	0	4	3	0	0	[illegible]	[illegible]

Chemical analyses of water from selected wells and springs, Kalispell Valley
Continued

oc-tion	Date of Collect-ion	Aquifer	Temp-erat-ure (F)	Iron (Fe)	Cal-cium (Ca)	Magne-sium (Mg)	Sodium Potas-sium (Na+K)	Bicar-bonate (HCO_3)	Carb-onate (CO_3)	Sulf-ate (SO_4)	Chlor-ide (Cl)	Fluo-ride (F)	Nit-rate (NO_3)	Diss-olved Solids	Total Hard-ness ($CaCO_3$)
28-21-1cb1	9/24/64	Deep artesian	--	0	33	12	12	177	0	5	5	0	0	140	133
28-21-2dd	11/4/64	Perched lacustrine sand	--	.60	43	19	33	247	0	28	9	0	13.3	246	184
28-21-6da	4/20/54	Flood-plain gravel	--	0	47	9	4	183	0	2	5	.1	0	175	155
28-21-7dd	2/10/55	Deep artesian	--	0	50	26	2	244	0	8	3	0	0	225	232
28-21-15aa	9/30/65	Flood-plain gravel	--	0	38	11	12	190	0	4	4	0	1.1	150	140
28-21-19bc2	2/29/65	Precambrian bedrock	--	.40	74	16	23	238	0	11	23	0	68	360	250
28-21-20bb	6/4/64	Deep artesian	--	.10	70	12	5	275	0	3	2	0	.5	238	225
28-21-20db1	9/29/65	Deep artesian	--	1.46	58	22	2	280	0	3	3	0	0	220	235
28-21-23ca	11/4/64	Flood-plain sand	--	.34	57	14	24	198	0	20	22	0	46.7	288	199
28-21-33cd2	9/29/65	Flood-plain sand	--	3.74	68	20	22	335	0	12	7	.1	0	296	250
28-21-35cb	9/29/65	Deep artesian	51	0	42	26	19	293	0	4	5	.1	0	212	210
29-20-3ba	9/22/64	Deep artesian	--	.76	35	17	18	223	0	5	6	.7	0	180	158

Chemical analyses of water from selected wells and springs, Kalispell Valley
Continued

oc-tion	Date of Collection	Aquifer	Temperature (F)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium Potassium (Na+K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids	Total Hardness ($CaCO_3$)
29-20-9ac1	10/1/58	Deep Artesian	--	.10	40	51	6	351	0	10	14	.1	2	316	321
29-20-9cc	9/22/64	Perched dune sand	49	.1	72	9	2	247	0	6	3	0	7.5	234	214
29-20-dc1	9/28/65	Shallow artesian	--	0	86	52	10	525	0	10	5	.2	0	430	430
29-20-18aa2	9/22/64	Deep artesian	50	.60	59	19	3	271	0	5	2	.2	0	214	224
29-20-33ca	11/2/64	Deep artesian	--	3.80	45	26	12	290	0	3	1	0	.5	228	219
29-21-2aa	9/29/65	Flood-plain gravel	--	0	38	10	9	177	0	4	3	.2	0	132	135
29-21-7dd	9/22/64	Perched dune sand	--	.1	122	40	28	244	0	18	52	.1	292	788	469
29-21-15cb	11/2/64	Flood-plain gravel	--	.14	51	14	2	216	0	3	2	0	1.4	180	184
29-21-19cb1	11/3/64	Deep artesian	49	2.10	53	2	23	201	0	18	3	0	0	184	143
29-21-20bc	11/3/64	Perched dune sand	51	0	53	20	11	235	0	14	11	0	21.2	250	214
29-21-21bd	9/23/64	Flood-plain gravel	--	0	57	12	0	223	0	2	2	0	1.8	194	194
29-21-34cc2	9/29/65	Flood-plain gravel	--	0	52	17	3	238	0	5	4	.1	0	210	200

Chemical analyses of water from selected wells and springs, Kalispell Valley
Continued

oc- tion	Date of Collect- ion	Aquifer	Temp- erat- ure (F)	Iron (Fe)	Cal- cium (Ca)	Magne- sium (Mg)	Sodium Potas- sium (Na+K)	Bicar- bonate (HCO_3)	Carb- onate (CO_3)	Sulf- ate (SO_4)	Chlor- ide (Cl)	Fluo- ride (F)	Nit- rate (NO_3)	Diss- olved Solids	Total Hard- ness ($CaCO_3$
29-22-3cd	11/3/64	Perched sand and gravel	--	0	43	26	0	235	0	5	0	0	8.0	194	214
29-22-10dc1	11/3/64	Deep artesian	--	0	37	4	12	134	0	20	2	0	0	116	107
29-22-21bb	9/29/65	Perched sand and gravel	--	0	58	22	19	268	0	10	8	0	40	280	235
29-22-27-dd	9/22/64	Deep artesian	--	0	46	38	4	320	0	8	3	0	5.3	246	230
29-22-34dc	11/3/64	Perched sand and gravel	--	0	59	12	0	229	0	4	1	0	1.1	180	199
B29-22-35dd2	11/3/64	Deep artesian	--	0	61	16	12	281	0	7	1	0	2.6	218	219
B30-20-19dd	9/22/64	Perched sand and gravel	47	.14	40	15	47	284	0	10	5	.1	14.3	280	260
B30-20-21da	9/28/65	Perched sand and gravel	--	0	80	18	15	342	0	9	5	.2	8.0	288	275
B30-20-27bd1	11/2/64	Deep artesian	66	0	12	5	335	827	12	0	52	4.4	2.7	848	51
B30-20-32cb	11/2/64	Perched dune sand	--	0	65	50	68	403	0	27	29	.2	135	600	367
B30-20-33bc	11/2/64	Deep artesian	--	0	41	32	9	287	0	10	3	.2	.5	222	235
B30-20-34ca	11/2/64	Perched dune sand	--	.14	126	11	39	381	0	29	12	.2	99	546	362

Chemical analyses of water from selected wells and springs, Kalispell Valley
Continued

oc- tion	Date of Collection	Aquifer	Temperature (F)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium Potassium (Na+K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total Hardness ($CaCO_3$)
330-21-9dd	9/29/65	Perched lacustrine sand	--	0	78	25	0	330	0	11	5	.2	5.3	300	295
B30-21-21dd	9/29/65	Perched dune sand	51	.12	124	30	39	387	0	35	44	.1	122	630	435
B30-21-26ba	9/23/64	Flood-plain gravel	--	0	61	13	5	244	0	9	3	12	3.2	210	204
B30-21-28ba1	9/22/64	Deep artesian	50	2.66	57	13	9	244	0	9	2	.1	2.1	204	194
B30-22-12ab	9/29/65	Deep artesian	--	1.16	50	17	30	310	0	0	4	0	0	228	195
B30-22-25aa	9/22/64	Deep artesian	--	.50	69	18	19	320	0	15	5	.1	0	258	245
B31-21-28cc	11/3/64	Deep artesian	--	0	35	15	3	183	0	1	3	0	0	142	148

APPENDIX V

ADOPTED BY THE MONTANA WATER POLLUTION CONTROL COUNCIL, OCTOBER 5, 1967.

WATER QUALITY WATER USE	ORGANISMS OF THE COLIFORM GROUP BY THE MOST PROBABLE NUMBER OR THE EQUIVALENT MEMBRANE FILTER METHODS, DURING ANY CONSECUTIVE 30-DAY PERIOD, AND USING A REPRESENTATIVE NUMBER AS SAMPLES, SHALL:	DISSOLVED OXYGEN MILLIGRAMS/LITER (MG/L) NO REDUCTION SHALL BE ALLOWED BELOW THE LISTED MINIMUM CONCENTRATION.
A-CLOSED. WATER SUPPLY FOR DRINKING, CULINARY AND FOOD PROCESSING PURPOSED SUITABLE FOR USE AFTER SIMPLE DISINFECTION. PUBLIC ACCESS AND ACTIVITIES SUCH AS LIVESTOCK GRAZING AND TIMBER HARVEST SHOULD BE STRICTLY CONTROLLED UNDER CONDITIONS PRESCRIBED BY THE STATE BOARD OF HEALTH.	AVERAGE KESS TGAB 50 OER 100 MILLILITERS (50/100 ML)	NOT APPLICABLE
A-OPEN. WATER SUPPLY FOR DRINKING, CULINARY AND FOOD PROCESSING PURPOSES SUITABLE FOR USE AFTER SIMPLE DISINFECTION AND REMOVAL OF NATURALLY PRESENT IMPURITIES.	AVERAGE LESS THAN 50/100 ML WHERE DEMONSTRATED TO BE THE RESULT OF DOMESTIC SEWAGE.	NOT APPLICABLE
B. WATER SUPPLY FOR DRINKING, CULINARY AND FOOD PROCESSING PURPOSES SUITABLE FOR USE WITH ADEQUATE TREATMENT EQUAL TO COAGULATION, SEDIMENTATION, FILTRATION, DISINFECTION, AND ANY ADDITIONAL TREATMENT NECESSARY TO REMOVE NATURALLY PRESENT IMPURITIES.	AVERAGE LESS THAN 1000/100 ML WHERE DEMONSTRATED TO BE THE RESULT OF DOMESTIC SEWAGE, WITH NOT MORE THAN 20 PERCENT OF THE SAMPLES EXCEEDING THIS VALUE	NOT APPLICABLE
C. BATHING, SWIMMING AND RECREATION.	SAME AS FOR "B" ABOVE.	NOT APPLICABLE
D-1. GROWTH AND PROPAGATION OF SALMONID FISHES AND ASSOCIATED AQUATIC LIFE, WATERFOWL AND FURBEARERS.	SAME AS FOR "B" ABOVE	7 MG/L
D-2. GROWTH AND MARGINAL PROPAGATION OF SALMONID FISHES AND ASSOCIATED AQUATIC LIFE, WATERFOWL AND FURBEARERS.	SAME AS FOR "D" ABOVE	6 MG/L
D-3. GROWTH AND PROPAGATION OF NON-SALMONID FISHES AND ASSOCIATED AQUATIC LIFE, WATERFOWL AND FURBEARERS.	SAME AS FOR "B" ABOVE	5 MG/L
E. AGRICULTURAL WATER SUPPLY INCLUDING IRRIGATION, STOCK WATERING AND TRUCK FARMING.	SAME AS FOR "B" ABOVE	NOT APPLICABLE
F. INDUSTRIAL WATER SUPPLY (OTHER THAN FOOD PROCESSING).	NOT APPLICABLE	NOT APPLICABLE

STATE OF MONTANA WATER POLLUTION CONTROL COUNCIL
WATER QUALITY CRITERIA
APPLICABLE AFTER REASONABLE OPPORTUNITY FOR DISCHARGES TO MIX WITH
RECEIVING WATERS AFTER REASONABLE
OPPORTUNITY FOR DISCHARGES TO MIX WITH
RECEIVING WATERS AS DETERMINED BY THE
MONTANA WATER POLLUTION CONTROL COUNCIL

pH	TURBIDITY	TEMPERATURE (°F)
INDUCED VARIATION WITHIN LISTED RANGE SHALL BE LESS THAN 0.5 pH UNIT. NATURAL pH OUTSIDE LISTED RANGE SHALL BE MAINTAINED WITHOUT CHANGE. NATURAL pH ABOVE 7.0 SHALL BE MAINTAINED ABOVE 7.0.	JACKSON CANDLE UNITS (JCU) ALLOWABLE INCREASE TO NATURALLY OCCURRING TURBIDITY:	ALLOWABLE CHANGES TO NATURALLY OCCURRING WATER TEMPERATURE:
NO CHANGE IN NATURAL pH SHALL BE ALLOWED.	NONE	NONE
6.5 TO 8.5	NONE	NOT APPLICABLE
6.5 TO 9.5	NONE IN SUFFICIENT QUANTITIES TO ADVERSELY AFFECT ESTABLISHED LEVELS OF TREATMENT	NOT APPLICABLE
SAME AS FOR "B" ABOVE	10 JCU	NOT APPLICABLE
SAME AS FOR "A-OPEN" ABOVE.	5 JCU	INCREASING: 32° TO 67° : 2° MAXIMUM ABOVE 67° : 0.5° MAXIMUM INCREASING: OVER 55° : 2° PER HOUR 55° TO 32° : 2° MAXIMUM PROVIDED THAT WATER TEMPERATURE MUST BE BELOW 40° DURING THE WINTER SEASON AND ABOVE 44° DURING THE SUMMER SEASON.
6.5 TO 9.0	SAME AS FOR "C" ABOVE	SAME AS FOR "D-1" ABOVE.
SAME AS FOR "B" ABOVE	SAME AS FOR "C" ABOVE	INCREASING: 32° TO 85° : 4° MAXIMUM ABOVE 85° : 0.5° MAXIMUM INCREASING: SAME AS FOR "D-1" ABOVE. PROVIDED THAT WATER TEMPERATURE MUST BE BELOW 40° DURING THE WINTER SEASON AND ABOVE 44° DURING THE SUMMER SEASON.
SAME AS FOR "B" ABOVE	NONE IN SUFFICIENT QUANTITIES TO ADVERSELY AFFECT THE USE INDICATED.	NOT APPLICABLE
SAME AS FOR "B" ABOVE.	SAME AS FOR "B" ABOVE	NONE IN SUFFICIENT QUANTITIES TO ADVERSELY AFFECT THE USE INDICATED.

RESIDUES OILS, FLOATING SOLIDS AND SLUDGE DEPOSITS. ALLOWABLE INCREASES ABOVE NATURALLY OCCURRING CONCENTRATIONS:	SEDIMENT OR SETTLEABLE SOLIDS ALLOWABLE INCREASE ABOVE NATURALLY OCCURRING CONCENTRATIONS:	TOXIC OR OTHER DELETERIOUS SUBSTANCES, PESTICIDES AND ORGANIC AND INORGANIC MATERIALS INCLUDING HEAVY METAL COMPOUNDS. (EXCEPTIONS FOR BENEFICIAL PURPOSES MAY BE AUTHORIZED BY THE MONTANA WATER POLLUTION CONTROL COUNCIL AND THE FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
NONE	NONE	NONE ALLOWED IN ADDITION TO CONCENTRATIONS NATURALLY PRESENT.
NONE IN SUFFICIENT QUANTITIES TO ADVERSELY AFFECT THE USE INDICATED.	NONE IN SUFFICIENT QUANTITIES TO ADVERSELY AFFECT THE USE INDICATED	CONCENTRATIONS OF CHEMICAL CONSTITUENTS SHALL CONFORM WITH THE 1962 U. S. PUBLIC HEALTH SERVICE DRINKING WATER STANDARDS. INDUCED VARIATIONS WITHIN THESE STANDARDS SHALL BE LIMITED TO AN INCREASE OF NOT MORE THAN TEN PERCENT OF THE CONCENTRATION PRESENT IN THE RECEIVING WATER.
NONE IN SUFFICIENT QUANTITIES TO ADVERSELY AFFECT ESTABLISHED LEVELS OF TREATMENT.	NONE IN SUFFICIENT QUANTITIES TO ADVERSELY AFFECT ESTABLISHED LEVELS OF TREATMENT.	CONCENTRATIONS OF CHEMICAL CONSTITUESNTS SHALL CONFORM WITH THE 1962 U. S. PUBLIC HEALTH SERVICE DRINKING WATER STANDARDS AFTER CONVENTIONAL TREATMENT.
SAME AS FOR "A-OPEN" ABOVE.	SAME AS FOR "A-OPEN" ABOVE.	CONCENTRATIONS OF CHEMICAL CONSTITUENTS SHALL BE MAINTAINED BELOW LEVELS KNOWN TO BE (OR DEMONSTRATED TO BE) OF PUBLIC HEALTH SIGNIFICANCE.
SAME AS FOR "A-OPEN" ABOVE.	SAME AS FOR "A-OPEN" ABOVE.	MAXIMUM ALLOWABLE CONCENTRATIONS SHALL BE LESS THAN ACUTE OR CHRONIC PROBLEM LEVELS AS REVEALED BY BIOASSAY OR OTHER APPROPRIATE METHODS. IN NO CASE SHALL THE FOLLWOING BE EXCEEDED: ONE-TENTH OF THE FOUR-DAY, MEDIAN TOLERANCE LIMIT (TLm 96) FOR SHORT RESIDUAL MATERIALS AND ONE-HUNDREDTH OF THE TLm 96 FOR PESTICIDES AND ORGANIC MATERIALS EXHIBITHING A RESIDUAL LIFE EXCEEDING 30 DAYS IN WATER.
SAME AS FOR "A-OPEN ABOVE.	SAME AS FOR "A-OPEN" ABOVE	SAME AS FOR D-1 ABOVE.
SAME AS FOR "A-OPEN" ABOVE.	SAME AS FOR "A-OPEN" ABOVE	SAME AS FOR "D-1" ABOVE.
SAME AS FOR "A-OPEN" ABOVE.	SAME AS FOR "A-OPEN" ABOVE.	CONCENTRATIONS SHALL BE LESS THAN THOSE DEMONSTRATED TO BE DELETERIOUS TO LIVESTOCK OR PLANTS OR THEIR SUBSEQUENT CONSUMPTION BY HUMANS.
SAME AS FOR "A-OPEN" ABOVE.	SAME AS FOR "B" ABOVE.	NONE IN SUFFICIENT QUANTITIES TO ADVERSELY AFFECT THE USE INDICATED.

NOTE: QUALITATIVE AND QUANTITATIVE EVALUATION OF WATER SAMPLES FOR COMPARISON WITH THESE CRITERIA SHOULD BE MADE IN ACCORDANCE WITH PROCEDURES SET FORTH IN THE TWELTH EDITION OF "STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER", APHA, AWWA, AND WPCF, 1965.

RADIOACTIVITY (LIMITS LISTED SHALL INCLUDE NATURAL BACKGROUND)	AESTHETIC CONSIDERATIONS NOT COVERED UNDER WATER QUALITY CRITERIA.
NO WASTES SHALL BE ALLOWED WHICH INCREASE RADIOACTIVITY ABOVE NATURAL BACKGROUND.	NO EVIDENCE OF MATTER OTHER THAN THAT NATURALLY OCCURRING.
CONCENTRATIONS OF RADIOACTIVE SUBSTANCES SHALL CONFORM WITH THE 1962 U. S. PUBLIC HEALTH SERVICE DRINKING WATER STANDARDS.	NO EVIDENCE OF MATTER OTHER THAN THAT NATURALLY OCCURRING, EXCEPT REAL COLOR SHALL NOT BE INCREASED MORE THAN TWO UNITS ABOVE NATURALLY OCCURRING COLOR.
SAME AS FOR "A-OPEN" ABOVE.	NO WASTES (INCLUDING PHENOLIC COMPOUNDS AND VISIBLE OILS) OFFENSIVE TO THE SENSES OF SIGHT, TOUCH, SMELL OR TASTE, NOT ATTRIBUTABLE TO NATURAL CAUSES, SHALL BE ALLOWED.
SAME AS FOR "A-OPEN ABOVE	SAME AS FOR "B" ABOVE
SAME AS FOR "A-OPEN ABOVE, EXCEPT WHERE CONCENTRATION FACTORS OF AQUATIC FLORA AND FAUNA EXCEED THE RECOMMENDED REDUCTION FACTORS, THAN MAXIMUM PERMISSIBLE LIMITS SHALL BE REDUCED BELOW ACUTE OR CHRONIC PROBLEM LEVELS.	NO WASTES (INCLUDING PHENOLIC COMPOUNDS AND VISIBLE OILS) OFFENSIVE TO THE SENSES OF SIGHT, TOUCH, SMELL OR TASTE, NOT ATTRIBUTABLE TO NATURAL CAUSES, SHALL BE ALLOWED. NO EXCESS NUTRIENTS WHICH CAUSE NUISANCE AQUATIC GROWTHS, TASTE AND ODOR CAUSING MATERIALS SHALL NOT EXCEED LEVELS WHICH CAUSE TAINTING OF THE FLESH OF EDIBLE SPECIES. REAL COLOR SHALL NOT EXCEED FIVE UNITS ABOVE NATURALLY OCCURRING COLOR.
SAME AS FOR "D-1" ABOVE.	SAME AS FOR "D-1" ABOVE
SAME AS FOR "D-1" ABOVE.	SAME AS FOR "D-1" ABOVE.
SAME AS FOR "A-OPEN" ABOVE.	WATER SHALL BE MAINTAINED IN A CONDITION NOT OFFENSIVE TO THE SENSES OF SIGHT AND SMELL.
SAME AS FOR "A-OPEN" ABOVE.	SAME AS FOR "E" ABOVE.

Appendix VI:

Regulations governing subdivision development.

SUBDIVISIONS

69-5001. Section 148. It is the public policy of this state to extend present laws controlling water supply and sewage disposal to include individual wells affected by adjoining sewage disposal and individual sewage systems.

69-5002. Section 149. As used in this chapter, unless the context clearly indicates otherwise, "subdivision" means any tract of land which is divided into two (2) or more parcels, any parcel of which is less than five (5) acres in size along an existing or proposed street, highway, easement, or right of way for sale, rent, or lease as residential, industrial, or commercial building lots described by reference to a map or survey of the property.

69-5003. Section 150. Any subdivision map or plat filed with the county clerk and recorder shall be subject to a sanitary restriction which must be recorded on, or attached to, the map or plat by the county clerk and recorder. No building or shelter which necessitates supplying water or sewage or waste disposal facilities for persons shall be erected until the sanitary restriction has been removed or modified. Before any restriction can be removed or modified by the county clerk and recorder, the map or plat of the subdivision must be submitted to the state department of health for their approval. Conditional approval may be given by the department after construction of a part of the water and sewage system, but permanent buildings shall not be occupied until the restriction has been removed or modified. The county clerk and recorder shall remove the sanitary restriction upon notice from the department that:

(1) the department approves plans and specifications for public water facility and sewage facilities; or

(2) the subdivision map or plat is approved by the department for a subdivision not providing public water or sewage systems.

69-5004. Section 151. The county clerk and recorder shall not file or record any map or plat showing a subdivision unless it complies with the provisions of this chapter.

69-5005. Section 152. The state board shall make rules, including adoption of sanitary standards, necessary for administration and enforcement of this chapter. The rules and standards shall provide the basis for approving subdivision maps or plats for various types of water and sewage facilities both public and private, and shall be related to size of lots, contour of land, porosity of soil, ground water level, type and construction of private water and sewage facilities, and other factors affecting public health.

MONTANA STATE DEPARTMENT OF HEALTH
Division of Environmental Sanitation

Regulation 51.300

APPROVAL OF WATER AND SEWER FACILITIES IN SUBDIVISIONS

Statutory Authority 69-5005
Adopted 5/27/61. Revised 9/21/63.
Revised 9/12/70.

Section 1. Definitions.

1.1 "Approved Potable Water Supply" means any water supply which has been approved by the State Department of Health.

1.2 "Approved Sewer System" means a sanitary sewer system which has been approved by the State Department of Health.

1.3 "Approved Public Water Supply System" means any installation or structure designed to provide domestic or potable water supply and which has been approved by the State Department of Health and serves or is intended to serve ten or more dwellings in a subdivision.

1.4 "Sewerage Facilities" means any installation or structure designed to provide sewage collection and disposal.

1.5 "Water Facilities" means any installation or structure designed to provide an approved potable water supply.

1.6 "Board of Health" means the State Board of Health of the State of Montana hereafter referred to as the Board.

1.7 "Department of Health" means the State Department of Health of the State of Montana hereafter referred to as the Department.

1.8 "Plat" means a plan, map, or chart, especially of a townsite.

1.9 "Well" means an artificial excavation that derives water from the interstices of the rocks or soils which it penetrates.

1.10 "Spring" means a surface feature where, without the agency of man, water issues from a rock or soil onto the land, the place of issuance being relatively restricted in size.

1.11 "Septic Tank" means a single-story settling tank in which the settled sludge is in immediate contact with the sewage flowing through the tank, while the organic solids are decomposed by anaerobic bacterial action.

1.12 "Subsurface Drainfield" means the process of sewage treatment in which the septic tank effluent is applied to land by distribution beneath the surface through open-jointed pipes or drains.

1.13 "Mechanical Sewage Treatment Device" means any mechanical device or equipment utilized in the treatment of wastewater by chemical or biological means.

1.14 "Subdivision" as defined by Section 69-5002: The word "Subdivision" as used in this act shall mean any tract of land which is hereafter divided into two or more parcels, any parcel of which is less than five acres in size, along an existing or proposed street, highway, easement or right-of-way for sale, rent or lease, as residential lots or residential or industrial or commercial building plots which are described by reference to a map or survey of the property or by any other method of description.

Section 2.0 Procedure for Submitting Plats for Water and Sewer for Subdivisions.

2.1 Submit plat and completed copy of E. S. 91 with supplemental information.

2.1.1 If public water and sewer system, so indicate, and submit plans for approval as required by Section 69-4905 (4) R.C.M., 1947. Obtain Department of Health approval.

a. Water and sewer installed--plat approved.

b. If water and sewer not installed but plans approved, may file plat with county clerk and recorder with "modified sanitary restriction" and furnish Department of Health with a statement that no structures will be occupied until the water and sewer systems are completed.

c. With approved plat--can build and occupy houses.

2.1.2 If individual water and/or sewer facilities or such individual facility coupled with public water or sewer system:

a. Submit information requested in regulations.

b. Show minimum size lot.

c. Indicate location of seepage tests for soil porosity.

d. Submit necessary information concerning groundwater.

e. If subdivider is building houses--

(1) Submit typical water and sewer facility plan.

f. If subdivider is selling lots for building--

(1) Submit statement that will be inserted in deed or contract requiring proper location of water and sewer system.

(2) Purchaser or subdivider submit individual water and sewer facility plan.

g. Plat will be approved upon receipt of acceptable proper information.

Section 3.0 General.

3.1 A plat together with the necessary information must be filed with the State Department of Health for approval of the water and sewage facilities in any subdivision proposed in Montana as defined above.

3.2.1 Plats are to be filed with the State Department of Health as required under Section 69-5003 as amended, which is quoted herewith:

"Title 69, Section 5003, R.C.M. Filing of Map or Plat Subject to Sanitary Restrictions--Submission to and Approval by State Department of Health --Removal or Modification of Restrictions. Any subdivision map or plat filed with the county clerk and recorder shall be subject to a sanitary restriction which must be recorded on, or attached to, the map or plat by the county clerk and recorder. No building or shelter which necessitates supplying water or sewage or waste disposal facilities for persons shall be erected until the sanitary restriction has been removed or modified. Before any restriction can be removed or modified by the county clerk and recorder, the map or plat of the subdivision must be submitted to the state department of health for their approval. Conditional approval may be given by the department after construction of a part of the water and sewage system, but permanent buildings shall not be occupied until the restriction has been removed or modified. The county clerk and recorder shall remove the sanitary restriction upon notice from the department that:

(1) the department approves plans and specifications for the public water facility and sewage facilities; or

(2) the subdivision map or plat is approved by the department for a subdivision not providing public water or sewage systems."

3.2.2 With the plat it will be necessary to submit plans for the type of water and sewer system proposed. If a public water supply and sewer system is to be installed, the data submitted should so indicate. Plans for these facilities will be submitted to the State Department of Health under present laws covering public water supply and sewer systems. These are set forth under Title 69, Section 4905 (4). When the water and sewers have been installed as approved, the plat would then be approved.

3.2.3 If the plans were approved but if the water and sewer lines were not installed, the conditional restrictions would remain until the water and sewer lines were installed. Until the conditional restriction was removed, parmanent buildings as set forth above could be erected but not occupied.

3.2.4 When service from an acceptable public or community water or sewer system is not available or feasible, an individual water supply and sewage disposal system may be considered acceptable providing it is installed in accordance with the standards set forth in these regulations. If the subdivider does not construct the dwellings, then he shall include in the deed a restrictive clause setting forth the procedures that shall be followed in the construction of the individual water and sewer facilities.

3.3 A plat may be filed with the county clerk and recorder when it has the approval of the State Department of Health. Such plat is filed without any sanitary restrictions. If the State Department of Health approval has not been obtained, it will be necessary that the county clerk and recorder place a restriction on the plat which will prohibit the construction of any buildings as set forth above in Section 3 until such "sanitary restriction" has been removed or modified by State Department of Health approval. The county clerk and recorder's responsibilities are set forth in Section 69-5003 of the law.

3.4 County clerk and recorder may file or record or accept for filing or recording any map or plat showing such subdivision of land in any city, town or county even though the State Department of Health approval has not been first obtained for the water and/or sewage disposal systems. When such is the case, a "sanitary restriction" shall be recorded on or attached to the map or plat by the county clerk and recorder. The subdivider shall be so informed at the time of filing that the "sanitary restriction" has been placed on the subdivision and that no dwellings, shelters, or buildings requiring water or sewage facilities shall be constructed until such sanitary restriction shall be removed or modified as set forth in these regulations.

3.5 The subdivider should he sell any lot or plots of ground within the subdivision while the sanitary restriction is still in force shall so indicate on the deed or other documents of sale, the restriction that no dwelling, shelter or building requiring water or sewage facilities shall be erected on the property until the sanitary restriction has been removed or modified in accordance with these regulations.

3.6 The sanitary restriction shall be removed or modified when all of the following conditions are fulfilled:

3.6.1 The subdivider, owner or other authorized person shall submit to the State Department of Health for review a plat or plan of the subdivision containing all of the information as set forth in these regulations.

3.6.2 The State Department of Health after review of the plat and accompanying information finds all of the requirements as set forth in these regulations and Section 69-5001 to 69-5005 as amended have been complied with.

3.6.3 A letter to be attached to the plat of the subdivision or an endorsement thereon from the State Department of Health approving the methods proposed or systems constructed for water supply and/or sewage disposal facilities is received and property attached by the county clerk and recorder.

Section 4.0 Submission of Plans.

4.1 A plan suitable for filing (with scale no smaller than one inch equals one hundred feet) to become a part of the permanent record of the State Department of Health shall be submitted to the Department for its review and approval. The plan shall indicate the size of lots, the topography, the proposed location for the water and sewage facilities, soil conditions, soil tests, and detailed information for all water and sewerage facilities. If additional copies of the map are to be approved for filing with the county clerk and recorder or if the owner desires to have copies, these additional copies shall be submitted at the time that the plans are reviewed. Criteria covering the requirements for satisfactory water supply systems and sewage disposal systems are included in Section 5 and 8 of these regulations.

4.2 Individual water supply and sewage disposal not provided by subdivider.

4.2.1 In the event that lots are sold by the subdivider without first constructing the water supply and/or sewage disposal systems in the manner approved by the State Department of Health on the filing plat, the subdivider shall then include in the deed or document of the transaction of sale a clause to the effect that the buyer shall install any water or sewage facility in accordance with the lot layout as previously approved by the State Department of Health.

Section 5. Criteria for Individual Water Supply Systems and Sewage Disposal Systems.

5.1 General.

5.1.1 The minimum size of lots may be regulated by local planning boards or other officials subject to minimum requirements of the State Board of Health as set forth below, but the size approved by the State Department of Health will be governed largely by the area necessary for the safe accommodation of individual water supply and sewage disposal systems. The lots must be sufficiently large to provide a safe separation between water supply and sewage disposal systems and to accommodate sewage disposal systems within the bounds of the property allowing a reasonable distance to the property lines. Sewage disposal systems must be kept a safe distance from the house and a proper distance from the property lines. Table I gives minimum safe distances in feet. A sufficient and definite set-back for the houses shall be determined based on the design of the sewage disposal system.

5.1.2 When an individual water supply and sewage system are to be provided to serve the property, the minimum size will be determined by the soil porosity, groundwater depth, amount of water usage anticipated and in general, will not be less than 20,000 square feet, but may be more if so indicated by the data submitted. When either an individual water system or an individual sewer system is to be provided to serve the property and the other service will be provided by the community, the lot size will be determined by the physical characteristics listed above, and in general, will be not less than 10,000 square feet, but may be more if so indicated by the applicable data and the rules and regulations pertaining thereto.

5.1.3 Included with each plan for a subdivision shall be typical layout or layouts of the individual lots showing the location and type of arrangements for water supply and sewage disposal which the developer or purchaser of the lot must follow when he erects a dwelling or shelter on the lot. If the size of lots, topography and soil conditions are uniform throughout the subdivision, a single typical lot layout will be sufficient. However, if topography or groundwater conditions may vary over the subdivision development, additional typical lot layouts shall be required.

5.2 A typical lot layout detail will include the following information and shall be drawn to scale.

5.2.1 All critical dimensions and distances, (for one lot, length and width; or for irregular shaped lots, dimensions of each side).

5.2.2 Location of house with distances from street and property lines.

5.2.3 Location of water supply with distances to sewers, sewage disposal device and the property lines.

5.2.4 Location of sewage disposal systems including septic tanks and subsurface drainfields, when used, with distances to water supply and property lines.

5.3 Water supply for individual lots shall include:

5.3.1 Detailed drawings or description of source of supply.

5.3.2 Details of construction of water system.

5.3.3 Methods for protection of water supply from contamination.

5.4 Sewage disposal systems for individual lots will include the following information:

5.4.1 Size of sewers.

5.4.2 Slope of sewers.

5.4.3 Size of sewage treatment device.

5.4.4 Means for disposal of effluent.

5.4.5 Size of drainfield and slope of drain lines if subsurface effluent disposal is utilized.

5.4.6 Distance to groundwater from ground surface during period of year groundwater is the highest.

5.5 Future expansion possibilities shall be indicated by dotted lines in instances where such expansion is probable.

Section 6.0 Individual Water Supply Systems.

6.1 General.

6.1.1 Individual water supply systems shall be constructed to provide an adequate quantity of water which is free of and protected from bacteriological contamination and is of a satisfactory chemical quality so as to cause no unfavorable physiological effects on those consuming the water.

6.1.2 The water system shall provide a sustained yield of at least five gallons per minute.

6.2 Location.

6.2.1 The water supply source shall be so located as to be adequately protected against contamination.

6.2.2 The minimum safe distances shown in Table I shall be maintained.

TABLE I

Minimum Safe Distances

FROM	TO			
	Septic Tank	Absorption Field	Seepage Pit	Absorption Bed
Well	50	100	100	100
Property line	10	5	10	10
Foundation wall	5	5	20	5
Water lines	10	10	10	10
Seepage pit	6	6	(1)	--

(1) Recommendation of Health Authority.

6.2.3 The location of water facilities shall be at least ten feet inside the property line.

6.3 Construction.

6.3.1 Water wells shall be constructed in accordance with the criteria set forth in State Department of Health Circular 12 attached to these regulations as Appendix B.

6.3.2 Springs shall be constructed in accordance with State Department of Health Circular 11, attached to the regulations as Appendix C.

6.3.3 Surface water shall be derived from an approved source and at an approved depth. All surface water shall be continuously and adequately disinfected at all times.

6.3.4 Other methods for obtaining water may be considered under special conditions, provided that detailed plans and explanations are submitted to the Department for review and approval at the time of filing the subdivision plat.

Section 7. Individual Sewage Disposal Systems.

7.1 General.

7.1.1 Adequate treatment shall be provided for all sewage and wastewater so that the effluent therefrom will not contaminate waters of the state.

7.1.2 Sewage treatment may be of any of the following devices:

a. Septic tank with subsurface effluent disposal either by means of drainfields or seepage pits.

b. Mechanical treatment utilizing chemical and/or biological processes with effluent disposal.

c. Mechanical treatment utilizing incineration of wastes.

d. Sanitary pit or vault privy, in remote areas where electricity is not available.

7.2 Location.

7.2.1 The sewage treatment facility shall be located convenient for use and shall not cause a nuisance, water pollution or public health hazard in any manner.

7.2.2 No sewage disposal device or system for individual dwellings shall be located within 100 feet horizontal distance from the maximum high water level of a 50-year flood from any river, stream, lake, pond or flowing watercourse. A distance greater than 100 feet from the maximum high water level may be required in some instances.

7.3 Construction.

7.3.1 Septic tanks and the respective means of effluent disposal shall be constructed to conform with the criteria set forth in State Department of Health--Cooperative Extension Service Bulletin 332 attached to these regulations as Appendix E.

The maintenance of a four-foot separation between the bottom of the trench or seepage pit and the water table is required to minimize groundwater contamination.

7.3.2 Construction of mechanical sewage treatment devices may be approved by the State Department of Health if a thorough review of the plans and specifications indicate the equipment and process meet all requirements of Section 7.1 above and there is assurance of competent operation.

7.3.3 Sanitary pit privies, when approved, shall be constructed in accordance with State Department of Health Circular 13, attached to these regulations as Appendix F.

7.4 Percolation Tests for Subdivisions.

7.4.1 An adequate number of tests shall be made (one per acre, or if soil conditions indicate, a greater number may be required) to adequately demonstrate the absorptive ability of the soil throughout the tract.

7.4.2 Each test hole shall be located by a key number on a topographic map of the tract.

7.4.3 Soil borings shall be made (one every five acres, or if sub-soil conditions indicate, a greater number will be required) to show clearly the type of soil existing beneath the absorption area. Borings should extend to a point at least six feet below the finished grade of proposed absorption trenches.

7.4.4 Individual lots. One percolation test shall be made (or if site conditions so indicate, several tests in separate holes spaced uniformly over the proposed site) within the proposed absorption field site.

7.4.5 Procedure. All percolation tests required shall be performed in accordance with the following:

a. Dig or bore the holes with horizontal dimensions of from 4 to 12 inches and vertical sides to the depth of the bottom of the proposed absorption device. Holes may be bored with 4-inch diameter post-hole type auger.

b. Roughen or scratch the bottom and sides of the holes to provide a natural surface. Remove all loose materials from the hole. Place about two inches of course sand or fine gravel in the hole to prevent bottom scouring.

c. Fill the hole with clear water to a minimum depth of 12 inches over the gravel. By refilling, if necessary, or by supplying a surplus reservoir of water (automatic siphon), keep water in hole for at least four hours, and preferably overnight. In sandy soils containing no clay, the above saturation procedure is not necessary and the test can be made after the water from one filling has seeped away.

d. Percolation rate measurements should be made on the day following the saturation process, except in sandy soils.

e. If water remains in the test hole after overnight saturation, adjust the depth to six inches over the gravel. From a fixed reference point, measure the drop in water level over a 30-minute period.

f. If no water remains in the hole after overnight saturation, add clear water to a depth of about six inches over the gravel. From a fixed reference point, measure the height of the water surface at approximately 30-minute intervals over a 4-hour period, refilling the hole to a depth of 6 inches as necessary. The drop which occurs during the final 30-minute period is used to calculate the percolation rate.

g. In sandy soils, or other soils in which the first six inches of water seeps away in less than 30 minutes after the overnight saturation period, the time interval between measurements can be taken as 10 minutes and the test run over a period of one hour. The drop which occurs in the final 10-minute period is used to calculate the percolation rate. See Table III, Bulletin 332.

Section 8.0 Form E. S. 91. Appendix G

8.1 Statement of information Form E. S. 91 shall be completed and shall be filed with the plan for the subdivision.

8.2 The measurements required in Form E.S. 91 must be accurately determined and must agree with the data shown on the plans.

8.3 Definite maximum and minimum elevations shall be indicated, not the average elevations. (Item 11).

8.4 Approximate distances under one mile shall be in hundreds of feet (Item 13 and 15).

8.5 If answers to any item need explanation, further information shall be provided. (A "yes" answer to Items 17 and 18 on Form E.S. 91 shall be explained in second part of the item).

8.6 The statements "not available" or "none" will not be considered as acceptable answers.

8.7 No action will be taken regarding the removal of sanitary restriction from a subdivision until all information noted on the last page of Form E.S. 91 has been submitted to the State Department of Health for review.

APPENDIX "A"

MONTANA STATE DEPARTMENT OF HEALTH
Division of Environmental Sanitation

Disinfection of Water Pipes, Wells and Reservoirs

It is necessary to disinfect all new water pipelines, wells and reservoirs before these structures are placed in regular service. This procedure should be followed by all. When lines are opened for repair or reservoirs are cleaned, disinfection should be used to eliminate the contamination which invariably follows.

Utmost care should be taken in the laying and handling of pipe to prevent dirt and foreign matter from entering the pipeline. All new pipe, before it is placed in position, should be thoroughly cleaned to remove dirt, gravel and other foreign material and also to make sure that there are no small animals lodged in it. Trench water should be prevented from entering the pipe by placing a plug or seal over the end of the pipe. When work is terminated for the day, the open ends of the pipe should be closed with a watertight plug to prevent animals from entering the pipeline. When an existing pipeline is opened for any reason, the same care must be taken to prevent trench water, foreign material and small animals from entering the pipe.

The disinfection of wells may be accomplished after the well has been completely constructed. It should be thoroughly cleaned of all foreign substances, including tools, timbers, ropes, debris of any kind, cement, oil, grease, joint dope and scum. The casing should be thoroughly swabbed, using alkali if necessary, to remove oil, grease or pipe dope. The well should then be disinfected with a chlorine solution. A chlorine solution of at least 50 parts per million should be added to the annual opening between the casing and the drop pipe. The pump equipment should then be started and operated until the odor of chlorine is detected at the discharge end of the pump. The equipment should then be shut off and the chlorine solution allowed to remain in contact with the pump and casing for a period of at least two hours. After the desired retention time, the equipment should again be operated and the well flushed until the odor of chlorine is no longer detected.

Pipelines can be disinfected by using liquid chlorine gas and water mixture, calcium or sodium hypochlorite and water mxitures, or chlorinated lime and water mixtures. The chlorine-bearing compounds should be placed in solution and added at the beginning of a pipeline extension or at the head of any valved section. It has been found, by using a corporation stop and a small injector pump, that the chlorine-bearing material can be placed into the pipeline very easily, if there is no pressure. An alternate method of treating water mains is to add the required amount of chemical at the joints of the pipe as they are being laid, then, upon completion of a section of the system, this portion can be slowly filled with water and allowed to stand the required time.

Chlorine solutions of at least 50 parts per million should be used in the disinfection of water systems. In some instances, more chlorine may be required as it is recommended that a chlorine residual of at least 10 parts per million be detected at the extremities of the system after the required holding time. A holding time of 24 hours is recommended for all water mains, and for new extensions. The retention time for disinfection of repairs in an existing system is dependent upon the necessity of getting the system back into service. In such instances, the longest retention time possible, up to 24 hours, should be used.

Valves should be manipulated so that the chlorine solution in the line being treated will not flow back into the line supplying water. All new valves and hydrants in the system should be operated to provide contact with the chlorine solution and be thoroughly disinfected.

After the required retention time, all the chlorine should be thoroughly flushed from the newly laid pipeline at its extremities, until the replacement water throughout its length shall, upon test, be proved comparable to the quality of the water served to the public from the existing water supply system.

There are a number of products on the market at the present time containing hypochlorite which can be used in the disinfection procedure. The following table, based on the use of hypochlorite with 70 percent available chlorine, gives the required amount of material to use in the disinfection of various size pipelines:

Pipe Size (Inside Diameter) Inches	Ounces or Pounds Hypochlorite Per 100 Feet of Pipe	Convenient Intervals for Hypochlorite Additions		
		(1 ounce)	(6 ounces)	(2 pounds)
4	0.67 ounce	144 feet	----	----
6	1.50 ounces	64 feet	----	----
8	2.67 ounces	36 feet	----	----
10	4.19 ounces	24 feet	----	----
12	6.03 ounces	16 feet	96 feet	----
16	10.72 ounces	----	60 feet	----
20	1.05 pounds	----	36 feet	----
24	1.51 pounds	----	24 feet	----
30	2.36 pounds	----	16 feet	84 feet
36	3.40 pounds	----	----	60 feet
42	4.62 pounds	----	----	48 feet
48	6.03 pounds	----	----	36 feet
60	9.43 pounds	----	----	24 feet

NOTE: The above dosage is based on a dry pipe in a dry ditch.

Other chlorine-bearing products, such as chloride of lime, Clorox, Purex, and other home bleaching materials may be used, but the amount of chlorine available is less; therefore, more material is needed to provide adequate disinfection. (One ounce HTH = 2.8 ounces chloride of lime = 14 ounces Clorox solution).

Water tanks, reservoirs, and basins should also be thoroughly disinfected after cleaning or upon being originally installed. For new tanks, the residue of oils, greases and other materials that may retain contaminating organisms should be thoroughly disinfected. To disinfect tanks and reservoirs, a chlorine solution containing 500 parts per million available chlorine should be used. This solution may be prepared in the following formula:

4.5 ounces of hypochlorite (70 percent available chlorine) to each 50 gallons water used.

A brush or spray may be used to make the application of the chlorine solution to the sides and bottom of the tank. The best results are obtained by allowing a period of two to four hours to elapse after the application before turning in the water to flush the tank. In all cases, the first water entering the tank should be permitted to run to waste to eliminate loose material not entirely removed by previous cleaning.

It is recommended that, upon completion of the chlorination of the system, water samples be collected and sent to the State Department of Health laboratory for examination. If contamination is found present in the water supply, the chlorination procedure must be repeated until the desired satisfactory results are obtained.

228-

AND
ENVIRONMENTAL SCIENCES

STATEMENT OF INFORMATION REGARDING WATER AND SEWERAGE SERVICE FOR REALTY SUBDIVISIONS

Form E.S. 91

The following statement is made and submitted with the plat of a proposed realty subdivision in the State of Montana under the provisions of Chapter 69-5001 to 69-5005,
vised Codes of Montana, 1947 and the Environmental Policy Act, Chapter 69-6504 (b) (

I. DESCRIPTION OF PROJECT.

1. Name of Subdivision ______________________ Location __________
(City or Count
Legal description: Section ________ Township ________ Range ________

2. Owner ____
(State name of person, company, corporation, or association owning the s
division. If organized, give name of officers.)

3. Business address ____

4. Area of subdivision ______ Number of lots __________ Families accommodated _
(Total size in acres)

5. Do you intend to build houses on this subdivision? _____ Do you intend to sell lots only? _____ Do you intend to build on some lots and sell others without buildings? _____.

6. Water Supply:

a. Proposed method of supplying water ______________________
(Describe in detail, giving name of
____
municipality, water district or company if a public water supply is to be
____
used.)

b. State approximate distance to nearest public water supply main of municipal or community system. ______________________________
(Give name of municipality, water district or company.

7. Sewerage Service:

a. Proposed method of collection and disposal of sewage ______________
(Give name of municipal-
____
ity or sewer district if public sewers are to be used.)

b. State approximate distance to nearest public sewer main of existing municip
or community system. ______________________________

8. Drainage and Runoff.

  a. Streets and roads.

    (1) State arrangements for disposing of surface water from streets and roads ________________________

    (2) Type of road surface proposed ________________________

    (3) Description of roadway drainage systems ________________________

    (4) Are stream crossings required? _____ If so, how will they be construc

    ____

    (5) Will there be cut and fill sections on streets and roads? _____ If so, indicate locations on topographic map along with a sectional drawing of the proposed cuts.

  b. Other drainage problem areas.

    (1) Does there exist any low or wet areas that require drainage? ________

    (2) Are there any watercourses, ditches or ravines which may be filled in? _____.

    (3) Indicate provisions for handling such problems if not shown on the pl

    ____

9. Subdivision owners who intend to build homes must submit the following additio information:

  a. Cellar drainage: Are cellar or footing drains to be installed? ________

    If so, how will drainage be disposed of? ________________________

  b. Laundry wastes: Are laundry tubs to be located in basement? ________

    If so, how will wastes be disposed of? ________________________

II. EXISTING ECOLOGICAL CONDITIONS.

  1. Present land use ________________________

  2. Nature of soil ________________________

    (Describe to a depth of 10 feet if tile fields are to be used f

    ____

    sewage disposal or 20 feet if seepage pits are proposed giving thickness of

    ____

    various strata such as top soil, clay, loam, sand, gravel, rock, etc.)

    By whom determined ________________ How determined ________________

3. Topography ____
(State whether ground is flat, rolling, steep, or gentle slope, etc. to be accompanied with a topographic map with contour intervals sufficient to show local topographic conditions.)

4. Will there be any grading (either cut or fill) one or more feet in depth? _____

If so, designate clearly on plans or describe in report.

5. Depth to water table: Maximum ____________________ Minimum ________________

Date determined ____

6. Has this land or any portion thereof ever been flooded? ______. If so, give maximum high water elevation and year of occurrence ________________________

7. Is this area located in the 50-year flood plain? ________________________

I. ENVIRONMENTAL ASSESSMENT.

1. Probable impact of the project on the environment.

2. Any probable adverse environmental effects which cannot be avoided.

3. Alternates considered with evaluation of each.

4. Relationship between local short-term uses of environment and maintenance and enhancement of long-term productivity.

5. Any irreversible or irretrievable commitment of resources.

IV. PUBLIC OBJECTIONS TO PROJECT, IF ANY, AND THEIR RESOLUTION.

V. AGENCIES CONSULTED ABOUT THE PROJECT.

1. State agency and representative's name ______________________

2. Local agency and representative's name ______________________

3. Is this subdivision or any part thereof located in an area under the control of local planning, zoning or other officials? ______________________

   If so, have these plans been submitted to such authorities? ______________

   Have these plans been approved or disapproved by such authorities? ________

It is hereby agreed that if the attached plans dated ______________ ____________ or a amendment or revision thereof, are approved by the State Department of Health and Envir mental Sciences, installation of water supply and sewage disposal facilities will be ma in accordance with the details thereof as shown on such approved plans. If the subdivi lands, shown on such plans are sold before such installations are made, it is agreed th all purchasers of lots will be furnished with a legible reproduction of the approved pl and they will be notified of the necessity of making installations in accordance with approved plans.

Dated ______________________________ Signature ______________________

Official Title ______________________

The statement must be signed by the owner of the land platted for subdivision or the responsible official of the company or corporation offering the same for sale.

Important Note:

The completed Form E.S. 91 must be accompanied by:

1. One general map showing exact location and approximate boundaries of subdivision. If subdivision is adjacent to a watercourse, indicate maximum high water (flood) elevation and year of occurrence.

2. One topographic map of subdivision with contour intervals to show the local ground conditions.

3. A print suitable for filing with the State Department of Health and Environmental Sciences together with such other tracings and prints (see below) as may be necessary for filing with the county clerk and recorder and owner of the subdivision showing:

    a. Subdivision layout, including streets, building lines, lot dimensions and other pertinent data.

    b. Existing and proposed water mains, if available. If public water supply is available, show existing and proposed water mains for all lots and submit a copy of the contract between the developer and the water works officials or a letter from such officials stating that an agreement has been reached regarding the supplying of such facilities.

    c. Existing and proposed sewers. If already approved by the Department, give date of approval; or, if not approved, application must be made and detailed plans of sewer extensions submitted by officials in charge of sewer systems in accordance with Title 69, Section 4901 to 4908.

    d. Details of a typical lot arrangement showing general location of well and septic tank, subsurface absorption devices, etc., (where either or both public water and sewerage services are inaccessible) plus the following:

        1) Development of well (giving sufficient details to show how the well will be developed and protected from pollution, its depth and strata penetrated).

        2) Cross section of soil showing depth of various strata to a depth of at least 10 feet if drainfields are to be used and at least 20 feet if seepage pits are proposed.

        3) Plan and section of all parts of sewage disposal system, giving all dimensions and grades.

        4) Actual field results of soil tests to determine absorptive capacity of soil (may be submitted with correspondence). This report is to be signed by a person recognized as qualified to make such tests.

ITEM III. ENVIRONMENTAL ASSESSMENT.

1. Probable impact of the project on the environment.

   Indicate the effect the development may have on the ecological systems of the area, the soil, the vegetation, the wildlife and other factors. What will be the primary and secondary effects of this project on the environment?

2. Any probable adverse environmental effects which cannot be avoided.

   Include such things as the effects on the land, air, water and environment and such thing as damage to the life systems, the effects of urban congestion, threats to health or other consequences adverse to the environmental goals for the area.

3. Alternates considered with evaluation of each.

   Objective evaluation of alternative actions. Analyze each alternate including cost and its impact on the environment. The alternative action must be reviewed in order not to overlook options which might have less detrimental environmental effects.

4. Relationship between local short-term uses of environment and maintenance and enhancement of long-term productivity.

What are the immediate and short-term potentials of this development as compared to the long-term projection of the effects on the environment? This should be considered from the perspective that each generation is trustee of the environment for succeeding generations. Will the development be detrimental to the preservation of this area for posterity?

5. Any irreversible or irretrievable commitment of resources.

Identify the extent to which the action may curtail the beneficial uses of the environment. What materials such as petroleum products, gas, timber, minerals, etc. will be committed to this development?

ITEM IV. PUBLIC OBJECTIONS TO THE PROJECT, IF ANY, AND THEIR RESOLUTIONS.

Include statements made by wildlife groups, nature groups, and environmentalists together with objections they may have to the project and how they may be overcomed.

ITEM V. AGENCIES CONSULTED ABOUT THE PROJECT.

These should include the State Department of Planning and Economic Development, the City-County Planning Board, County Commissioners, and other reviewing authorities together with the names of the persons to whom the material was submitted. A statement is needed to the effect that the development is or is not under the control of local planning, zoning, or other officials and if these agencies do have jurisdiction, have they had the opportunity to review the proposal? If there is such an agency, what was its action regarding the proposal?

The completed Form E. S. 91 must be accompanied by:

1. One general map showing exact location and approximate boundaries of subdivision. If subdivision is adjacent to a watercourse, indicate maximum high water (flood) elevation and year of occurrence.

2. One topographic map of subdivision with contour intervals to show the local ground conditions.

3. A print suitable for filing with the State Department of Health and Environmental Sciences together with such other tracings and prints (see below) as may be necessary for filing with the county clerk and recorder and owner of the subdivision showing:

   a. Subdivision layout, including streets, building lines, lot dimensions and other pertinent data.

   b. Existing and proposed water mains, if available. If public water supply is available, show existing and proposed water mains for all lots and submit a copy of the contract between the developer and the water works officials or a letter from such officials stating that an agreement has been reached regarding the supplying of such facilities.

   c. Existing and proposed sewers. If already approved by the Department, give date of approval; or if not approved, application must be made and detailed plans of sewer extensions submitted by officials in charge of sewer systems in accordance with Title 69 Section 4901 to 4908.

d. Details of a typical lot arrangement showing general location of well and septic tank, subsurface absorption devices, etc. (where either or both public water and sewerage services are inaccessible) plus the following:

1) Development of well (giving sufficient details to show how the well will be developed and protected from pollution, its depth and strata penetrated).

2) Cross section of soil showing depth of various strata to a depth of at least 10 feet if drainfields are to be used and at least 20 feet if seepage pits are proposed.

3) Plan and section of all parts of sewage disposal system, giving all dimensions and grades.

4) Actual field results of soil tests to determine absorptive capacity of soil (may be submitted with correspondence). This report is to be signed by a person recognized as qualified to make such tests.

Appendix VII

Recommendations of the Bureau of Sports Fisheries and Wildlife, Spokane, Washington, area office, August, 1972.

Alternate Plan Flathead Basin

A. No large storage dams or diversions in the Flathead Basin above Kerr Dam.

B. Minor projects that are properly planned and developed such as the Stillwater Diversion Project and other minor water diversions shall be permitted with the following stipulations:

1. Corridors along all natural and major developed waterways associated with the project to be placed in public ownership. Width of these corridors to be determined by State and Federal fish and wildlife agencies. These corridors to be planted with native grasses and shrubs if needed.

2. At least 5% of project lands or an equivalent amount of off project lands to be dedicated to fish and wildlife purposes and deeded to fish and wildlife agencies (State or Federal). Higher percentages of land exchange to be required depending on fish and wildlife potential of project lands. Such lands to be selected from the following:

    a. Class 6 lands.

    b. Selected class 1-4 lands. To be selected by the originators of the project and State and Federal fish and wildlife agencies.

    c. Lands that go wet as a result of project.

    d. Off project lands of high value.

3. Acquisition, initial development and maintenance costs to be nonreimbursable project costs.

4. Management to be the responsibility of the Montana Fish and Game.

5. Sufficient quality and quantity of water will be retained or supplied to each natural waterway to maintain and support potential levels of aquatic life.

6. Artificial fish habitat will be developed on suitable streams developing from irrigation return flows or waste waters. Settling ponds for silt removal will be provided.

7. Natural streams and lakes should not be damaged by any project. Where damages cannot be avoided, for each mile of natural stream or acre of natural lake affected by the project, an equal amount of stream or lake including not less than 1/8 mile on each side of the stream or around the lake will be legally protected from future development. Where exceptional values are involved no development will be permitted.

8. Fish hatcheries and spawning channels will be supplied to supplement fish production where deemed necessary by fish and wildlife agencies.

9. Stream changes will be avoided.

10. Domestic livestock will be excluded from all project lands acquired for fish and wildlife, with the following exceptions:

    a. Where grazing is compatible with fish and wildlife use.

    b. Where special water access is required for stock watering. Such areas to be fenced to exclude livestock from the remainder of the area. Fencing to be a project cost.

11. All areas disturbed by construction associated with the project to be revegetated with native grasses and shrubs if deemed necessary by fish and wildlife agencies.

12. All project associated lands lost to fish and wildlife from roads, powerlines, barrow areas and associated facilities will be compensated for on an acre-for-acre basis.

13. Where rare or endangered species are involved the project will be generally opposed.

14. Money will be provided to the State and/or Federal fish and wildlife agencies by the project for pre and post project studies and surveillance. Such studies to be identified for specific proposed projects by the State and/or Federal fish and wildlife agencies.

State of Montana

State Department of Health

JOHN S. ANDERSON, M.D.
EXECUTIVE OFFICER

HELENA, MONTANA 59601

October 6, 1971

TO: Persons Receiving Montana Water Quality Criteria, Water Use Classifications and Policy Statements

Attached are "Water Quality Criteria", "Water Use Classifications", and "Policy Statements" as adopted by the Montana Water Pollution Control Council, together with a map of the surface water classifications to facilitate understanding these classifications.

It is felt that with these water quality standards, the clean waters in Montana will be maintained and those waters that are currently degraded will be improved to meet the criteria established. It is the intent of this office, through our control program and the standards, to maintain the best water possible in Montana.

Yours very truly,

C. W. Brinck

Claiborne W. Brinck, P.E., Director
Division of Environmental Sanitation

CWB:sh

Attachments

MONTANA STATE WATER POLLUTION CONTROL COUNCIL

POLICY STATEMENTS

1. Quality of waters classified for multiple use shall be governed by the most stringent criteria listed for any use.

2. The Council has classified as "A-Closed" only those waters on which access and other activities are presently controlled by the utility owner. If other uses are permitted by the utility owner, these waters shall be reclassified "A-Open" or lower. Conversely, waters in the "A-Open" classification, if shown to meet the "A-Closed" criteria, may be so classified by the Council at the request of the utility owner.

   Where "A-Open" water is used for swimming and other water contact sports, a higher degree of treatment may be required for potable water use.

3. The water quality standards are subject to revision (following public hearings and, in the case of interstate streams, concurrence of the Federal Water Pollution Control Administration) as technical data, surveillance programs, and technological advances make such revisions desirable. There are waters in the state on which little water quality data are presently available. Water quality criteria for these waters were established to protect existing and future water uses on the basis of the most representative information available.

   In some cases, particularly in eastern Montana, waters have been classified "B" and "C" where the upper ends of the streams will probably be suitable for this use while the lower ends will not. However, not enough data is available to determine where the "B" and "C" designation should be dropped. Whenever a water supply or swimming area is developed, the regulations and the advice of the State Board of Health should be acquired. As time permits, data will be obtained and the classifications reviewed.

4. As used in the Water Quality Criteria, the phrases "natural," "naturally present," and "naturally occurring" are defined as conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been applied. Waters below existing dams will be considered natural.

5. It is the intent of the criteria that the increase allowed (temperature for example) above natural conditions is the total allowable from all waste sources along the classified stream.

6. Although the water quality criteria specify minimum dissolved oxygen concentrations, it shall be the policy of the Council to require the best practicable treatment or control of all oxygen-consuming wastes in order to maintain dissolved oxygen in the receiving waters at the highest possible level above the specified minimums.

7. For treatment plant design purposes, stream flow dilution requirements shall be based on the minimum consecutive 7-day average flow which may be expected to occur on the average once in 10 years.

8. Where sampling stations and points of mixing of discharges with receiving waters as mentioned in the water quality criteria are to be established on interstate waters, the concurrence of the Federal Water Pollution Control Administration will be solicited.

9. It is not the intent of these criteria to provide for a swimming water immediately below an existing treated domestic sewage outfall.

10. Where common treatment is practicable, it is the policy of the Council to restrict the number of sewer outfalls to a minimum.

11. Tests or analytical procedures to determine compliance with standards will, insofar as practicable and applicable, be made in accordance with the methods given in the twelfth edition of "Standard Methods for the Examination of Water and Waste Water" published by the American Public Health Association, et al, or in accordance with tests or analytical procedures that have been found to be equal or more applicable.

12. Because of conflicting testimony, it is the intent of the Water Pollution Control Council to obtain additional information on temperatures and fisheries on waters below existing steam generating stations at Billings and Sidney on the Yellowstone River. This can probably be best accomplished by a cooperative study between the utility, State Fish and Game Department, Federal Water Pollution Control Administration, and the Montana State Department of Health.

13. Insufficient information is available for establishing fixed sediment criteria at this time. Until standards can be set, reasonable measures, as defined by the Water Pollution Control Council, must be taken to minimize sedimentation from man's activities.

14. Waters whose existing quality is better than the established standards as of the date on which such standards become effective will be maintained at that high quality unless it has been affirmatively demonstrated to the state that a change is justifiable as a result of necessary economic or social development and will not preclude present and anticipated use of such waters. Any industrial, public or private project or development which would constitute a new source of pollution or an increased source of pollution to high quality waters will be required to provide the necessary degree of waste treatment to maintain high water quality. In implementing this policy, the Secretary of the Interior will be kept advised in order to discharge his responsibilities under the Federal Water Pollution Control Act, as amended. Note: A statement with similar meaning is included in the revised Water Pollution Control Act (H. B. No. 85, Chapter 25, Montana Session Laws, 1971)

MINIMUM TREATMENT REQUIREMENTS

1. Domestic sewage -- the minimum treatment required for domestic sewage shall be secondary treatment or its equivalent with the understanding that properly designed and operated sewage lagoons will meet this requirement.

2. Industrial wastes -- the minimum treatment required for industrial wastes shall be secondary treatment or its equivalent.

WATER USE DESCRIPTIONS AND APPLICATION

Water use classifications assigned to the Columbia and Missouri Basin and the Hudson Bay drainage in Montana are described as follows:

"A-Closed"--Water supply for drinking, culinary, and food processing purposes, suitable for use after simple disinfection. Public access and activities such as livestock grazing and timber harvest should be strictly controlled under conditions prescribed by the State Board of Health.

The Council has classified as "A-Closed" only those waters on which access is presently controlled by the utility owner. If other uses are permitted by the utility owner, these waters shall be reclassified "A-Open-D_1" or lower.

"A-Open-D_1"--Water supply for drinking, culinary, and food processing purposes suitable for use after simple disinfection and removal of naturally present impurities. Water quality shall also be maintained suitable for the use of these waters for bathing, swimming and recreation (See "Note" below), (where these waters are used for swimming and other water contact sports, a higher degree of treatment may be required for potable water use); growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; agricultural and industrial water supply. Therefore, these waters shall be held suitable for "A-Open", "C", "D", "E", and "F" uses but may not necessarily be used for all such purposes.

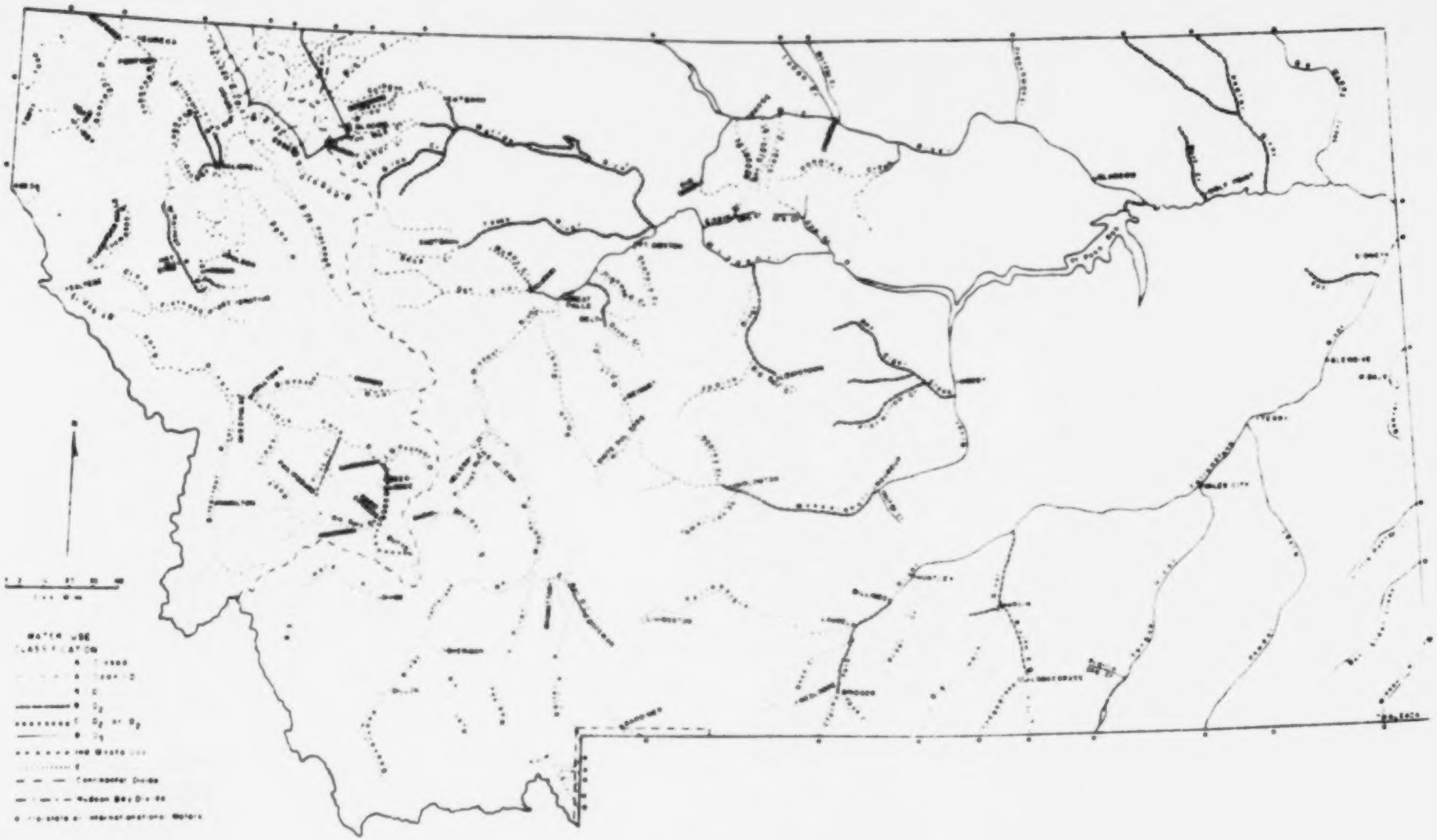
Waters in this class, if shown to meet the "A-Closed" criteria, may be so classified by the Council at the request of the utility owner.

All waters within the boundaries of national parks and nationally designated wilderness, wild, or primitive areas in Montana are classified "A-Open-D_1" except those adjacent to developed areas such as Snyder Creek through the community of Lake McDonald and Swiftcurrent Creek below the Many Glacier Chalet, both in Glacier National Park. Also, Georgetown, Flathead, and Whitefish Lakes and Lake Mary Ronan are classified as "A-Open-D_1" as are some streams presently used for domestic water supply.

Note: Common sense dictates that swimming and other water contact sports are inadvisable within a reasonable distance downstream from sewage treatment facility outfalls.

"B-D_1"	The quality of these waters shall be maintained suitable for drinking, culinary and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection, and any additional treatment necessary to remove naturally present impurities; bathing, swimming, and recreation (see Note under "A-Open-D_1"); growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; agricultural and industrial water supply. Therefore, "B-D_1" equals "B", "C", "D_1", "E", and "F".
"B-D_2"	The quality of these waters shall be maintained suitable for the uses described for "B-D_1" waters except that the fisheries use shall be described as follows: "Growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers." Therefore, "B-D_2" equals "B", "C", "D_2", "E", and "F".
"B-D_3"	The quality of these waters shall be maintained suitable for the uses described for "B-D_1" waters except that the fisheries use shall be described as follows: "Growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers." Therefore, "B-D_3" equals "B", "C", "D_3", "E", and "F".
"C-D_2"	The quality of these waters shall be maintained suitable for bathing, swimming, and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; agricultural and industrial water supply. Therefore, "C-D_2" equals "C", "D_2", "E", and "F".
"D_2'	The quality of these waters shall be maintained for growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; agricultural and industrial water supply. Therefore, "D_2" equals "D_2", "E", and "F".
"E"	The quality of these waters shall be maintained for agricultural and industrial water supply uses and "E" shall equal "E" and "F" uses.
"F"	The quality of these waters shall be maintained suitable for industrial water supply uses, other than food processing.

MONTANA WATER POLLUTION CONTROL COUNCIL - SURFACE WATER USE CLASSIFICATIONS OF MONTANA, OCT. 5, 1967


WATER USE
CLASSIFICATION
Continental Divide
Hudson Bay Divide

WATER USE CLASSIFICATION

COLUMBIA BASIN

Clark Fork River Drainage

Clark Fork River:

Warm Springs Drainage to Myers Dam	A-Open-D_1
Remainder of Warm Springs Drainage	B-D_1
Silver Bow Creek (mainstem) from the confluence of Yankee Doodle and Blacktail Deer Creeks to Warm Springs Creek	For industrial waste use.
Yankee Doodle Creek Drainage to and including the Butte water supply reservoir	A-Closed
Remainder of Yankee Doodle Creek Drainage	B-D_1
Blacktail Deer Creek Drainage except portion of Basin Creek listed below:	B-D_1
Basin Creek Drainage to and including the Butte water supply reservoir	A-Closed
Remainder of Basin Creek Drainage	B-D_1
All other tributaries to Silver Bow Creek from the confluence of Yankee Doodle and Blacktail Deer Creeks to Warm Springs Creek	B-D_1
Clark Fork River (mainstem) from Warm Springs Creek to the Little Blackfoot River	C-D_2
Tin Cup Joe Creek Drainage to the Deer Lodge water supply intake	A-Closed
Remainder of Tin Cup Joe Drainage	B-D_1
Clark Fork River Drainage from the Little Blackfoot River to the Idaho line except those portions of tributaries listed below:	B-D_1
Georgetown Lake and tributaries above Georgetown Dam	A-Open-D_1
Flint Creek Drainage from Georgetown Dam to the Farm-to-Market Highway No. 348 bridge about one mile west of Philipsburg except those portions of tributaries listed below:	B-D_1
Fred Burr Lake and headwaters from source to the outlet of the lake	A-Closed

Flint Creek (mainstem) from Farm-to-Market Highway No. 348 bridge about one mile west of Philipsburg to the Clark Fork River	B-D_2
South Boulder Creek Drainage to the Philipsburg water supply intake	A-Open-D_1
Remainder of South Boulder Drainage	B-D_1
All other tributaries to Flint Creek from F-to-M Highway 348 bridge to the Clark Fork River	B-D_1
Rattlesnake Drainage to the Missoula water supply intake	A-Closed
Remainder of Rattlesnake Drainage	B-D_1
Packer and Silver Creek Drainage (tributaries to the St. Regis River) to the Saltese water supply intakes	A-Open-D_1
Remainder of Packer and Silver Creek drainages	B-D_1
Ashley Creek Drainage to the Thompson Falls water supply intake	A-Closed
Remainder of Ashley Creek Drainage	B-D_1
Pilgrim Creek Drainage to the Noxon water supply intake	A-Open-D_1
Remainder of Pilgrim Creek Drainage	B-D_1
All tributaries of Clark Fork River not otherwise mentioned	B-D_1

Flathead River

Flathead River Drainage (except tributaries in Glacier National Park or in nationally designated Wild, Wilderness, or Primitive areas) except tributaries and lakes or reservoirs listed below:	B-D_1
Essex Creek Drainage to the Essex water supply intake	A-Closed
Remainder of Essex Creek Drainage	B-D_1
Snyder Creek (mainstem) through the community of Lake McDonald in Glacier National Park to Lake McDonald	B-D_1
Stillwater River (mainstem) from (but excluding) Logan Creek to the Flathead River	B-D_2

Whitefish Lake and its tributaries	A-Open-D_1
Whitefish River (mainstem) from the outlet of Whitefish Lake to the Stillwater River	B-D_2
Haskill Creek Drainage to the Whitefish water supply intake	A-Open-D_1
Remainder of Haskill Creek Drainage	B-D_1
Remainder of Whitefish River Drainage	B-D_1
Remainder of Stillwater River Drainage	B-D_1
Ashley Creek Drainage to and including Smith (Kila) Lake	B-D_1
Ashley Creek (mainstem) from Smith Lake to bridge crossing on the airport road about one mile south of Kalispell	B-D_2
Ashley Creek (mainstem) from bridge crossing on the airport road to the Flathead River	E
All tributaries to Ashley Creek from Smith Lake to the Flathead River	B-D_1
Flathead Lake and its tributaries except Flathead River above the Lake (as listed above) Swan River and a portion of Hellroaring Creek as listed below, but including Swan Lake proper and Lake Mary Ronan	A-Open-D_1
Swan River Drainage (except Swan Lake proper)	B-D_1
Hellroaring Creek Drainage to the Polson water supply intake	A-Closed
Remainder of Hellroaring Creek Drainage	B-D_1
(Simply as a note for clarification, the Flathead River below the highway bridge at Polson to Paradise is included in the "B-D_1" classification of the Flathead River Drainage listed above.)	
Crow Creek Drainage to road crossing at Section 16, T20N, R20W about two and a half miles southwest of Ronan, except the portion of Second Creek listed below:	B-D_1
Second Creek Drainage to the Ronan water supply intake	A-Closed
Remainder of Second Creek Drainage	B-D_1
Crow Creek (mainstem) from road crossing in S16, T20N, R20W to the Flathead River	B-D_2

Tributaries to Crow Creek from road crossing in S 16 to the Flathead River	B-D_1
Little Bitterroot River Drainage to Hubbart Reservoir	B-D_1
Little Bitterroot River (mainstem) from Hubbart Reservoir Dam to the Flathead River	B-D_2
Tributaries to the Little Bitterroot River from Hubbart Reservoir Dam to the Flathead River except Hot Springs Creek listed below:	B-D_1
Hot Springs Creek Drainage to the Hot Springs water supply intake	A-Closed
Hot Springs Creek (mainstem) from the Hot Springs water supply intake to the Little Bitterroot River	E
Tributaries to Hot Springs Creek (if any) from the Hot Springs water supply intake to the Little Bitterroot River	B-D_1
Mission Creek Drainage to the St. Ignatius water supply intake	A-Open-D_1
Mission Creek Drainage from the St. Ignatius water supply intake to U.S. Highway No. 93 crossing about one mile west of St. Ignatius	B-D_1
Mission Creek (mainstem) from U.S. Highway No. 93 crossing to the Flathead River	B-D_2
Tributaries to Mission Creek from the U.S. Highway No. 93 crossing to the Flathead R.	B-D_1

Kootenai River Drainage

Kootenai River Drainage from the border of Canada to the Idaho border (including the Yaak River), except the tributaries listed below:	B-D_1
Deep Creek Drainage (tributary to the Tobacco River) to the Fortine water supply intake	A-Open-D_1
Sullivan Creek Drainage to the Rexford water supply intake	A-Closed
Rainy Creek Drainage to the Zonolite Company water supply intake	A-Open-D_1

Rainy Creek (mainstem) from the Zonolite Company water supply intake to the Kootenai River	D_2
Flower Creek Drainage to the Libby water supply intake	A-Open-D_1

MISSOURI BASIN

Missouri River Drainage

Missouri River:

Missouri River Drainage to the Sun River in Great Falls except tributaries listed below:	B-D_1
East Gallatin River (mainstem) (tributary to the Gallatin River, tributary to the Missouri River) from Montana Highway No. 293 crossing about one-half mile north of Bozeman to, but excluding, Dry Creek about five miles east of Manhattan	B-D_2
Remainder of the East Gallatin River Drainage except the tributaries listed below:	B-D_1
Lyman and Sourdough (Bozeman) Creek Drainages to the Bozeman water supply intakes	A-Closed
Remainder of the Lyman and Sourdough Creek Drainages	B-D_1
Hyalite Creek Drainage to the Bozeman water supply intake	A-Open-D_1
Remainder of the Hyalite Creek Drainage	B-D_1
Big Hole River Drainage (tributary to the Jefferson, tributary to the Missouri River) above Divide	A-Open-D_1
Remainder of the Big Hole Drainage	B-D_1
Rattlesnake Creek Drainage (tributary to the Beaverhead River, tributary to the Jefferson River) to the Dillon water supply intake	A-Open-D_1
Remainder of the Rattlesnake Creek Drainage	B-D_1
Indian Creek Drainage (tributary to the Ruby River, tributary to the Beaverhead River) to the Sheridan water supply intake	A-Open-D_1
Remainder of the Indian Creek Drainage	B-D_1
Basin Creek Drainage (tributary to the Boulder River, tributary to the Jefferson River) to the Basin water supply intake	A-Open-D_1
Remainder of the Basin Creek Drainage	B-D_1
Prickley Pear Creek Drainage to the Montana Highway No. 433 crossing about one mile northwest of East Helena, except the tributaries listed below:	B-D_1

McClellan Creek Drainage to the East Helena water supply intake	A-Open-D_1
Remainder of the McClellan Creek Drainage	B-D_1
Prickley Pear Creek (mainstem) from the Montana Highway No. 433 crossing about one mile northwest of East Helena to its mouth	E
Tributaries of Prickley Pear Creek from the Montana Highway No. 433 crossing to its mouth except those listed below:	B-D_1
Ten Mile Creek Drainage to the Helena water supply intake	A-Open-D_1
Remainder of Ten Mile Creek Drainage	B-D_1
Willow Creek Drainage (tributary of the Smith River, tributary to the Missouri River) to the White Sulphur Springs water supply intake	A-Closed
Remainder of the Willow Creek Drainage	B-D_1
Missouri River (mainstem) from Sun River to Rainbow Dam	B-D_2
Missouri River Drainage from Rainbow Dam in Great Falls to the North Dakota line except the portion of the mainstem and the tributaries listed below:	B-D_3
Sun River Drainage to, but excluding, Muddy Creek near Vaughn	B-D_1
Muddy Creek Drainage	E
Sun River (mainstem) from Muddy Creek to the Missouri River	B-D_3
Tributaries (if any) to the Sun River from Muddy Creek to the Missouri River	B-D_1
Belt Creek Drainage to and including Otter Creek except portion of O'Brien Creek listed below:	B-D_1
O'Brien Creek Drainage to the Neihart water supply intake	A-Open-D_1
Remainder of the O'Brien Creek Drainage	B-D_1
Belt Creek (mainstem) from Otter Creek to the Missouri River	B-D_2
Tributaries to Belt Creek from Otter Creek to the Missouri River	B-D_1
Highwood and Shonkin Creek Drainages	B-D_1

Marias River Drainage except tributaries listed below:	B-D_2
Cutbank Creek Drainage to, but excluding, Old Maid Miller Coulee in Cutbank except the portion of Willow Creek listed below:	B-D_1
Willow Creek Drainage to the Montana Highway 464 crossing about one-half mile north of Browning	B-D_1
Willow Creek (mainstem) from the Montana Highway No. 464 crossing to Cutbank Creek (also included in the Marias River Drainage classification above)	B-D_2
Tributaries (if any) to Willow Creek from the Montana 464 crossing to Cutbank Creek	B-D_1
Cutbank Creek (mainstem) from Old Maid Miller Coulee to Birch Creek (also listed under Marias above)	B-D_2
Tributaries to Cutbank Creek from, but excluding Old Maid Miller Coulee (which is "B-D_2") to Birch Creek	B-D_1
Birch Creek Drainage except tributaries listed below:	B-D_2
Two Medicine Creek Drainage to and including the Badger Creek Drainage	B-D_1
Midvale Creek Drainage to the East Glacier water supply intake	A-Closed
Remainder of Midvale Creek Drainage	B-D_1
Summit Creek Drainage to the Summit water supply intake	A-Closed
Remainder of Summit Creek Drainage	B-D_1
Two Medicine Creek (mainstem) from Badger Creek to Birch Creek	B-D_2
Tributaries to Two Medicine Creek from Badger Creek to Cutbank Creek	B-D_1
Teton River Drainage to and including Deep Creek near Choteau	B-D_1
Remainder of Teton River Drainage	B-D_2
Eagle Creek Drainage to but excluding Dog Creek	B-D_1

Remainder of Eagle Creek Drainage	B-D_3
Judith River Drainage to Big Spring Creek	B-D_1
Big Spring Creek Drainage to the Mill Ditch Headgate near the southern city limits of Lewistown	B-D_1
Big Spring Creek (mainstem) from the Mill Ditch Headgate to the Judith River	B-D_2
Tributaries to Big Spring Creek from the Mill Ditch Headgate to the Judith River	B-D_1
Judith River (mainstem) from Big Spring Creek to the Missouri River	B-D_2
Tributaries to the Judith River from Big Spring Creek to the Missouri River	B-D_1
Cow Creek Drainage to but excluding Al's Creek	B-D_1
Remainder of Cow Creek Drainage	B-D_3
Musselshell River Drainage to and including Hopley Creek near Harlowton	B-D_1
Musselshell River Drainage from Hopley Creek to but excluding Half Breed Creek near Roundup except American Fork listed below:	B-D_2
American Fork Drainage	B-D_1
Musselshell River Drainage from and including Half Breed Creek to Fort Peck Reservoir except Flatwillow Creek Drainage listed below:	B-D_3
Flatwillow Creek Drainage (may be the Box Elder Creek Drainage) near Mosby	B-D_2
Missouri River (mainstem) from Fort Peck Dam to the Milk River	B-D_2
Milk River Drainage from source (or from the Glacier National Park Boundary) to the International Boundary	B-D_1
Milk River Drainage from the International Boundary to the Missouri River except the tributaries listed below:	B-D_3
Big Sandy Creek Drainage above Big Sandy	B-D_1
Remainder of Big Sandy Creek Drainage	B-D_3
Beaver, Box Elder, and Clear Creek Drainages (all near Havre)	B-D_1

People's Creek Drainage to and including the South Fork of People's Creek	B-D_1
Remainder of People's Creek Drainage	B-D_3
Wolf Creek Drainage near Wolf Point	B-D_2
Poplar River Drainage	B-D_2

Yellowstone River Drainage

Yellowstone River Drainage from the Yellowstone Park Boundary to the Laurel water supply intake	B-D_1
Yellowstone River Drainage from the Laurel water supply intake to the Billings water supply intake, except the tributaries listed below:	B-D_2
Clark's Fork River Drainage from source to the Wyoming line and from the Wyoming line to and including Jack Creek near Bridger	B-D_1
Clark's Fork River (mainstem) from Jack Creek to the Yellowstone River	B-D_2
Tributaries to the Clark's Fork River from Jack Creek to the Yellowstone River except the West Fork of Rock Creek listed below:	B-D_1
West Fork of Rock Creek Drainage to the Red Lodge water supply intake	A-Open-D_1
Remainder of West Fork of Rock Creek Drainage	B-D_1
Yellowstone River Drainage from the Billings water supply intake to the North Dakota line except the tributaries listed below:	B-D_3
Pryor Creek Drainage	B-D_1
Big Horn Drainage above but excluding William's Coulee near Hardin	B-D_1
Big Horn Drainage from and including William's Coulee to the Yellowstone River except the Little Big Horn listed below:	B-D_2
Little Big Horn Drainage above and including Lodgegrass Creek near Lodgegrass	B-D_1
Remainder of the Little Big Horn Drainage	B-D_2

Tongue River (mainstem) from Tongue River Reservoir to but excluding Prairie Dog Coulee	B-D_2
Remainder of the Tongue River Drainage	B-D_3
Fox Creek Drainage near Sidney	B-D_2

Little Missouri and Belle Fourche Drainages:

All waters	B-D_3

HUDSON BAY DRAINAGE

All waters within Glacier National Park except the portion of Swiftcurrent Creek listed below:	A-Open-D_1
Swiftcurrent Creek (mainstem) from the Many Glacier Chalet to Lake Sherbourne	B-D_1
All waters outside Park from Park Boundary to the International Boundary	B-D_1